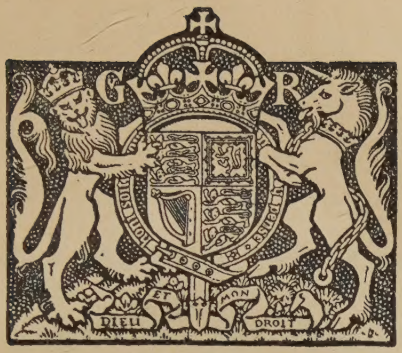

MINISTRY OF AGRICULTURE AND FISHERIES,
DEPARTMENT OF AGRICULTURE FOR SCOTLAND, AND
MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

REPORTS

on the work of

Agricultural Research Institutes

and on certain other agricultural investigations in the

United Kingdom.

1929-1930.

This volume, which aims at presenting in a convenient form the progress of agricultural research carried out with the aid of State funds during the Academic Year 1929/1930 at Research Institutes and other centres in the United Kingdom, is planned on the same lines as its predecessor, the volume covering the Academic Year 1928/1929. (1)

Attention is drawn to a publication which serves as a complement to these volumes, viz.: the annual volumes of "Abstracts of Papers on Agricultural Research in the United Kingdom." (2)

Attention is also drawn to the Appendix to the present volume containing the names and addresses of Directors of Research Institutes and persons in charge of investigations at other centres. Those desiring further information regarding any subject dealt with in the reports should address their enquiries to the Director or other person concerned.

Ministry of Agriculture and Fisheries,
10, Whitehall Place,
London, S.W.1.

May, 1931.

(1) The volume for 1928/1929 is obtainable from the Ministry at the above address, free and post free.

(2) The volumes for 1926/1927, 1927/1928, 1928/1929 and 1929/30 are obtainable from the Ministry at the above address, price 1/- net each volume, post free.

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* Included by the courtesy of the Department of Scientific and Industrial Research.

I.

RESEARCH INSTITUTE INVESTIGATIONS.

A.

SOILS, PLANT NUTRITION and PLANT PHYSIOLOGY.

A

SOILS, PLANT NUTRITION

and

PLANT PHYSIOLOGY

1. ROTHAMSTED EXPERIMENTAL STATION.

The purpose of the work is to obtain information about the soil and the growing plant in health and disease and to put this information into a form in which experts and good farmers can use it.

The work is carried on in the laboratory, the pot culture house, the heavy land farm at Rothamsted and the light land farm at Woburn ; typical experiments are then repeated on farms in various parts of the country. Although these outside experiments involve considerable labour they are cheerfully undertaken by farmers concerned and the results afford a valuable check on those obtained at Rothamsted and at Woburn. Fortunately it appears that the Rothamsted results are a very fair representation of the average of those obtained elsewhere.

The experiments on *Sugar beet* have shown over a period of several years that nitrate of soda is usually the best of the nitrogenous fertilisers but that it should go on with the seed ; top dressings are not so good. Nitrogenous fertilisers usually depress the percentage of sugar in the roots but the increase in yield may more than make up for this. Potash manure salts are better than sulphate or muriate of potash : salt has a distinctly useful effect. None of the fertilisers, however, act as well as they should and there is clearly something keeping down our yields that we do not yet understand. We are not satisfied with our present varieties but they may not be wholly responsible : this year's programme includes combined cultivation and manurial experiments that should give much new information.

There is always a discrepancy between the percentage of sugar recorded on the farm and that reported from the factory, the factory figure being invariably the lower.

The experiments on *potatoes* are satisfactorily showing the most effective combination of the various fertilisers. The crop is sensitive to correct feeding : without increasing the expenditure on artificial manure it is possible to add one or two tons per acre to the yield simply by ensuring a better balance. The quantity of potash (reckoned as K_2O) in the artificial fertiliser should be about double that of the quick acting nitrogen (reckoned as N) and the total amount of chlorine in the mixture should not be more than double the nitrogen. These proportions are not rigid and they break down in certain special conditions : the light sandy soil at Tunstall, for instance, gave over 13 tons of potatoes with superphosphate and nitrate of soda alone without any potash : and it could hardly be expected that potash should increase this, nor did it ; this, however, is quite exceptional.

The relationship of the phosphate is being worked out. The different varieties differ somewhat in their response to phosphate ; on a large commercial farm at Holbeach British Queens responded satisfactorily while King Edward under identical conditions did not, although it gave the heavier yield.

At the suggestion of some of the market gardeners experiments were made to compare the organic with the usual mineral fertilisers ; in no case, however, did the organic fertilisers show any advantage ; superphosphate was as good as or better than bone supplying equal amounts of phosphate and sulphate of ammonia as good as or better than dried blood or fish meal supplying equal amounts of nitrogen. At Woburn rape cake has proved somewhat inferior to sulphate of ammonia or nitrate of soda for cereals. Cyanamide, which is the cheapest form of nitrogen tested, gave at Woburn slightly better results for potatoes than those given by sulphate of ammonia.

Barley.—For the past two years an interesting variation has been introduced into the classical Hoos field experiment ; two varieties have been grown, Spratt and Plumage Archer, in alternate half drill strips, then harvested separately so as to obtain the differential response of these varieties to the widely different fertiliser treatments then given. Certain differences are observed during growth but they are greatly reduced before harvest time ; a third year's trial is necessary before the value of the differences can be assessed.

In the other experiments nitrate of soda has proved rather better than other nitrogenous fertilisers, and cyanamide somewhat inferior to sulphate of ammonia.

Forage Crops.—The improvements in manufacture of fertilisers assure abundant supplies at relatively low prices. Further, the increasing area of grass and the reduction in the arable land has upset the old equilibrium between arable stock farming and grass stock farming which used to be adjusted in the spring and autumn sales ; it has emphasised the importance of increasing the supply of winter keep for the animals.

The experiments of the last few years have shown that nitrogen and phosphorus in fertilisers are readily convertible into protein and phosphorus compounds in foodstuffs, and when account is taken also of the carbohydrate or starch equivalent produced by the fertiliser it appears that an expenditure of 10*s.* to 20*s.* on fertiliser can give 30*s.* worth of animal food.

Some crops are more efficient than others in transforming cheap fertiliser into animal food. Among the most promising are the mixtures of cereals with vetches or peas and beans which can be cut green or made into hay in June or July or allowed to ripen and threshed, giving grain and straw. A number of mixtures are grown under different fertiliser treatments, and full feeding analyses are made of the resulting crops. In actual yield, barley with vetches or peas has given more grain but less straw than oats with vetches or peas. Nitrogenous manuring increased the straw but not the grain. The grain yields were slightly better in the pea mixtures than in the vetch mixtures, especially where nitrogenous manure was given.

The effects of fertilisers vary according to the soil and the season. The differences due to soil are being studied by comparing the results of 50 years' experiments on wheat and barley at Woburn with those of similar experiments at Rothamsted; this is being done in great detail in the Statistical Department with the aid of a grant from the Royal Agricultural Society of England. On the light land at Woburn farmyard manure has been less effective than might be expected: 1 lb. of nitrogen in the form of sulphate of ammonia or nitrate of soda has been as effective for these cereal crops as 4 lb. of nitrogen in the form of farmyard manure, even when allowance is made for the physical effect on the soil. At this rate the farmyard manure cannot be priced at more than about 6*s*. per ton. The experiments do not show how the manure would compare for roots and potatoes. On the other hand rape cake has been more useful, only 1½ lb. of its nitrogen being needed to give the same action as 1 lb. nitrogen in nitrate of soda.

Sulphate of ammonia and nitrate of soda have had much the same action at Woburn as at Rothamsted. Sulphate of ammonia has given increases at the rate of 6½ bushels of barley and 6 bushels of wheat per cwt. of dressing, and nitrate of soda at the rate of 8½ of barley and 6½ of wheat. The Rothamsted figures agree closely with these in spite of the great difference in the soil.

Our outside experiments also give on the average figures of the same order, the general average for sulphate of ammonia being 6·5 bushels of barley and 5 of wheat per cwt. of dressing. We have no evidence of any consistent effect of soil type on the effectiveness of nitrogenous fertilisers excepting only that on the black fen soils they are less effective. Potassic and phosphatic fertilisers do, however, vary in action to some extent according to soil, and this is being studied at several centres.

The effect of weather is more marked and of the various weather conditions rainfall seems to be the most potent.

The effect of *weather on fertiliser efficiency* and crop yield is studied in the Statistical Department. The rainfall at Rothamsted is lowest in spring and highest in autumn—the peak of the curve is in November, but it has not always been so—forty years ago it was at the end of September, and seventy years ago at the beginning of September. There are signs that the peak is now moving backwards again and that we are reverting to a period of wetter Septembers and drier Novembers. This swinging of the seasons has apparently happened before; the somewhat scanty records suggest that it happened in the 18th century and again in the middle of the 19th century.

A detailed study of the effect of rain, inch by inch and month by month, on the Rothamsted wheat under different schemes of fertiliser treatment has already been made, and now the same methods have been applied to the Rothamsted barley. The rain falling in the six months when barley is not in the ground is just as important as that falling while the barley is growing, but the

effects of rain in different months vary with the manurial treatment. The plants on potash-starved plots 20 and 2A seem specially to suffer after a wet winter.

Temperature is less important than rainfall, but it plays a great part in the early days of the plant life. On the average a rise in soil temperature of 1° F. shortens the time between sowing the seed and appearance of the plant above ground by one day for spring sown cereals, and by 1½ to 2 days for autumn sown cereals at Rothamsted. Swedes and turnips, however, are not affected by soil temperature, it being usually sufficiently high by the time they are sown.

Grass Land Investigations.

Grass differs from ordinary arable crops in that it is not one crop but several, all growing so closely together that they compete for the available food and water. The final crop, therefore, depends on two factors : the ability to grow in the natural conditions of the field, and the ability to compete with the other plants also present.

Investigations on competition have been going on for the past two years, five of the more important grasses being grown singly and in admixture each with the other. Of those tried Italian Rye grass was the most aggressive in competition with others, and the rest came out in the following order :—

Perennial Rye grass, Timothy, Cocksfoot and Rough Stalked meadow grass—each grass crowding out those that follow in the list, but being crowded out by those that precede it. The order was the same both in 1928–9 and 1929–30, except that Perennial Rye grass and Timothy were interchanged in the former year.

Manuring of Grass Land.—Fertilisers produce three distinct effects on grass land : up to a certain point they increase the quantity of their particular nutritive element in the plant (e.g., nitrogenous fertilisers increase the nitrogen, phosphatic fertilisers increase the phosphorus, and potassic fertilisers increase the potassium) : they may, and often do, increase the growth and they usually alter the herbage, encouraging some kinds of plants more than others.

Nitrogenous manures have their greatest effect when applied in spring : they suffer considerable loss when used in autumn. Given in February or March they cause a rapid uptake of nitrogen in the plant shown by a darkening of the green colour ; if the soil and other conditions permit this is followed by an increased growth of young grass valuable for early grazing. Sulphate of ammonia used alone, however, while increasing the early growth greatly reduced the wild white clover and so reduced the later growth of herbage.

Phosphatic manures have the opposite effect on the herbage : they tend to increase the clover. They increase the amount of phosphorus taken up by the plant : usually there is no visible

sign of the additional phosphorus except on starved soils: the grazing animal, however, can usually detect it and chooses the phosphate treated land.

In all the tests so far made superphosphate has put more phosphorus into the herbage in the first year after application than any other phosphatic fertiliser: the next in order has been high soluble basic slag and the least effective low soluble slag and mineral phosphate. In no case, however, is much of the added phosphate recovered: so far not more than 10 per cent. at best. Up to a certain point the increased uptake of phosphorus goes on, whether the yield increases or not.

The yields of hay come out in the same order as phosphorus uptake, superphosphate being best, high soluble slag next, then low soluble slag and mineral phosphate.

Certain new basic slags have recently been produced which, although of low solubility, were said to be more effective than the old ones. Pot and field experiments have not supported this claim; the new slags seem little better than the old ones. Like them they have a certain lime value on acid soils, being in our tests as effective as their own weight of calcium carbonate. On certain soils, however, they may, like other slags, so much stimulate the decomposition of the organic matter that the carbonic acid produced more than balances their lime effects on the soil reaction.

Lucerne.—The dry summer of 1929 afforded some remarkable demonstrations of the value of lucerne: where all the fields around were parched and brown, the lucerne land was green and full of food for the animals. Until recently there has often been difficulty in getting the crop to start. This was traced by Dr. H. G. Thornton, of the Bacteriology Department, to the absence of the necessary organisms from the soil, and he worked out a process by which the organisms could be bred and added with the seed. The experiments proved so successful that farmers began to ask for supplies and the demands soon became so great that we could no longer cope with them and the process was, therefore, handed over to Messrs. Allen and Hanburys on terms arranged with the knowledge and approval of the Ministry of Agriculture and the Royal Agricultural Society, who had made grants towards the cost of the field work. The arrangements are working smoothly, and Messrs. Allen and Hanburys report that the demand during 1930 was more than double that of the previous year, enough cultures being distributed to inoculate between 4,000 and 4,500 acres. The Ministry's return shows that the acreage of lucerne in the country increased by over 4,000 acres in spite of the fall in acreage of arable land. Experiments are in hand to devise methods whereby seedsmen can inoculate the seed before sale; this will save much trouble both in distribution and on the farm.

Meanwhile scientific work has continued on the relation between the organism and the plant. It was shown in a previous Report

that nodules do not appear on the roots of the young plant till the first true leaf appears : as soon as that opens a substance is extruded from the root which enables the bacteria to attack and enter. The first visible sign of attack is the curling of the root hairs, this also is determined in part by a root excretion, and, like the entry of the bacteria, it can be brought about before the true leaf appears if the seedling is growing among rather older plants on which the leaves have opened. Thus it appears that the excretion from one plant can serve for others as well as for itself. The curling, however, is also determined by an excretion from the bacteria, though whether the excretion is identical with that from the plants cannot yet be stated. The bacterial excretion is effective on plants other than those which the bacteria can enter ; e.g., lucerne bacteria can curl the root hairs of peas but they cannot enter. The various leguminous bacteria do not live at peace with each other in the soil : lucerne bacteria reduce the number of nodules formed on clover roots by clover bacteria : they cannot themselves enter the clover root, but they prevent the clover organisms from doing so. Something happens to the organisms in the soil after the soil has been cropped with the leguminous plant for a time : clover growing on a soil that had carried clover every fourth year had fewer nodules than clover growing on adjacent soil where no clover had been grown for 80 years, and this held true whether there was inoculation or not.

The Cultivation of the Soil.

Cultivation is one of the costliest items in the arable farmers' programme : its high cost, indeed, is sending many of them into grass farming. It is not yet reduced to a science and consequently cannot be treated by advisors with the same confidence as manuring.

The Physics Department at Rothamsted is endeavouring to work out a science of cultivation and it is proceeding in two ways. Experiments are made in the field to try and discover by dynamometer and other tests what cultivation does to the soil and to see what other methods have the same effect. Other studies are made in the laboratory to explain the field measurements and observations and to work out the physical properties of the soil, especially those related to cultivation such as stickiness, friction, plasticity, permeability ; to discover also what is meant by tilth and crumb structure. Cultivation with a rotary implement which makes a seed bed in one operation is being compared with the normal cultivation which requires two or three processes to do the same thing. So far the rotary is on the average nearly equal to the ordinary cultivation, but with differences in certain seasons, which, when explained, will afford information of great value for further developements.

The effect of sheep folding on light land has been studied at Woburn. The compacting of light soil obtained by sheep is different from that given by implements : it extends to a greater depth

and it lasts longer : the top three inches of the soil is mainly affected. It gives also a coarser tilth. It does not, however, increase the water-holding power of the soil; on the contrary, the trodden part was if anything somewhat the drier. The physical properties under investigation for the purpose of explaining tilth and crumb structure include the plasticity of the soil, the electrical conductivity and dielectric constants of soil suspensions, the specific gravity in the crumb and finely powdered states before and after pumping out all air.

Fallowing.—The effect of fallowing on weed suppression is being studied by Dr. Brenchley and Miss Warington. Poppies were not much reduced by fallowing, but *Alopecurus agrestis* was ; it came back again, however, immediately the fallow was over. Four years' consecutive fallowing and cultivation reduced the weed seeds much more than two years, but poppies are still germinating in a sample of soil put under glass in 1925 and so rigidly protected that no seed from outside can possibly enter ; the soil has been cultivated eight times a year ever since, all seedlings being removed directly they are identified.

The Utilisation of Results of Agricultural Experiments.

Agricultural problems rarely present clear cut simple issues ; they are usually complicated by a number of factors some of which are themselves highly complex : in experimental work there is always, therefore, an element of doubt whether the result is obtained because of the treatment or in spite of it. Experimenters in the past have got round the difficulty by repeating the experiment a number of times, and if they frequently obtain the same result they have felt justified in attributing it to the treatment and not to some other and unknown cause. In the original Rothamsted experiments Lawes and Gilbert repeated their field trials for 20 years before publishing much about them : they then could speak with considerable certainty.

It is not practicable in modern conditions to use this long time method and another was introduced at Rothamsted in 1919. Mathematicians have developed methods for studying figures and tracing any relationships that may exist between one set of observations and another : the result can be expressed as the odds that one result is related to another. Dr. R. A. Fisher was appointed to apply these methods at Rothamsted and he has designed arrangements of field experiments which allow of the calculation of the odds that the result is due to the treatment and not to something else. These field methods have been in use for several years, and have proved easily workable and a great advance on the old ones.

Dr. Fisher has also devised methods for studying masses of data such as agricultural experimental farms and stations have accumulated. It is now possible, for example, to trace the effect

of rain week by week on crops grown under different manurial or cultural conditions, and so to learn definitely how crops and manures behave in different seasons. Great masses of data that have accumulated at the various experimental farms in the country and have not hitherto been used can now be examined with a high degree of assurance that any information concealed therein will soon be discovered. Recently he has developed a new method, the Analysis of Variance, which is of special value for handling masses of figures. It is regularly used at Rothamsted for the most diverse purposes : in the bacteriological work for the study of the hourly fluctuations of the numbers of bacteria in the soil ; in the entomological department for studying bees and other insects; in the field work for assessing the trustworthiness of the results; and in the chemical department for extracting information from the masses of figures accumulated by a succession of industrious analysts.

The Composition of the Soil : Soil Analysis.

For many years past chemists have been analysing soils, and the work has now been systematised by the setting up of soil surveys in different parts of the country. Great quantities of analytical data have accumulated which, however, are difficult to interpret by the older methods. This new appliance, the Analysis of Variance, has been used by Dr. Crowther and he has extracted from the figures some highly interesting and valuable results.

He has begun on the many analyses of clay fraction of the soil that have been made. The molecular ratio of silica to alumina (SiO_2/Al_2O_3) has been recognised as an important soil character but it varies a good deal from soil to soil with little or no apparent regularity. Dr. Crowther now shows that the ratio is determined partly by the early history of the soil and partly by the rainfall and temperature conditions under which it now stands, and further he has been able to assess the relative effects of these different factors. As the rainfall increases the clay becomes less siliceous (*i.e.*, the ratio SiO_2/Al_2O_3 decreases) : as temperature increases the clay becomes more siliceous (*i.e.*, the ratio SiO_2/Al_2O_3 increases) : in the clays examined a rise of 1°F. had about the same effect as a reduction by one inch of the annual rainfall, when both temperature and rainfall increase the composition remains constant if 1°F. rise of temperature is accompanied by one inch (more accurately 0·97 inches) of rain. This close connection between rainfall and temperature arises because the effective agent is not the amount of rain, but the quantity of water leaching through the soil, and this falls off as the temperature rises because a larger proportion evaporates. The relation between rainfall and temperature with the amount of drainage through the Rothamsted drain gauge is almost identical with that of rainfall and temperature with the SiO_2/Al_2O_3 ratio.

The ratio also depends on the geological history of the soil. Soils which have been little disturbed during their lifetime, e.g., soils derived from igneous rocks which have not been moved far, have a low SiO_2/Al_2O_3 ratio : soils that have been much reworked (e.g., the soils of the south-east of England) have a high (SiO_2/Al_2O_3) ratio. Much reworking in water therefore has the opposite effect from high rainfall ; apparently silica is returned to the clay during this process.

Dr. Crowther has further studied the relationship between soil type and climate. Rainfall is the more important factor in dry conditions and temperature the more important in humid conditions. The difference between the various soils in the highly leached group, with the exception of the extreme podsol, does not lie in the alumino-silicates of their clay fraction but in the distribution of the iron oxide in the various layers of the soil : in high temperature weathering this is deposited near to the surface giving red soils, in low temperature its solution or suspension is more stable and is leached down to lower depths.

This work is being continued and will, it is hoped, systematise and make useful a large mass of data which at present has little value.

Another important contribution from the Chemical Department has cleared up some difficult problems in connection with compensation for unexhausted values of lime. Estimates so far made of the time that lime might be expected to last in the soil do not agree well. Dr. Crowther now finds that the rate of loss of lime and the extent of the loss depend not only on the amount of leaching but also on the amount of exchangeable calcium in the soil : if this is high the whole of the added lime is soon lost : if it is low the lime remains in the soil and is a permanent improvement. A uniform scale of compensation which takes no account of this soil character therefore operates unfairly and a better one could now be drawn up.

Considerable progress has been made with the solution of the difficult green manuring problem at Woburn. The tares and mustard ploughed into the soil decompose with formation of nitrate which is rapidly washed out, especially from the tares, leaving only little for the wheat, and in consequence it starves for want of nitrogen.

The Composition of Crops.

Dr. Bishop's work on the composition of barley grain carried out under the Institute of Brewing scheme shows that the composition and amounts of the various proteins in the grain depend only on the total amount of nitrogen present and not at all on how it got there—whether as the result of manuring, of soil properties, or weather conditions. The simplest connection is shown by hordein : all varieties of two-rowed barleys so far examined contain the same

amount of hordein for any given total weight of nitrogen per grain : for a nitrogen percentage N the amount of hordein is :—

$$0{\cdot}422\ N - 0{\cdot}023$$

The other nitrogen compounds, the salt soluble compounds and the glutelin differ in their proportions according to the variety. In the fully matured grain these proportions depend only on the total nitrogen content and the variety ; they are independent of soil, season and manuring.

Dr. Bishop further shows how from a knowledge of the percentage of nitrogen in the barley grain and of the thousand corn weight it is possible to calculate the amount of malt extract obtainable after malting, a figure of great importance to maltsters. He has constructed a slide rule which shows this figure at a glance and thus furnishes information which hitherto could be obtained only after a long, difficult and expensive analysis. Another simple calculation shows also from the barley figures the diastatic power to be expected in the malt cured at any given temperature : the closeness of agreement between the values expected and those found can be used as a measure of the efficiency of the malting process.

These results are proving of great importance to maltsters and brewers.

A survey is in hand of the malting barley production in Britain, showing the yields and qualities that can be expected in different parts of the country and the comparison of quality of British and foreign barleys.

Soil Micro-organisms.

Reference has already been made to the investigations on the micro-organisms which led to the development of a method of growing lucerne successfully where this could not be done before. Several other investigations on micro-organisms are in progress.

Purification of sugar beet effluent.—The microbiological process developed at Rothamsted has now been so far perfected that it gives a purification of 95 per cent. when working at the rate of 50 gallons of liquid per cubic yard of filter per day. This is higher than is needed in practice and accordingly the factory work at Colwich has been discontinued and attention confined to further laboratory investigation of the various outstanding microbiological difficulties which sooner or later will give trouble unless they are definitely dealt with at the outset. The chemical and microbiological changes are being studied in detail.

The decomposition of straw by micro-organisms.—Dr. Norman finds that the most striking change is the rapid decomposition of the cellulose : this accounts for most of the total loss. At first some of the himicelluloses (unfortunately named because they are entirely different from cellulose) decompose rapidly, but most of them remain with the lignin as the undecomposed residue. The decom-

position is brought about mainly by fungi, not, however, by one organism alone but by many acting together. Much heat is evolved during the process but this is associated with the decomposition of hemicellulose especially its pentose units and possibly the uronic units, rather than of cellulose. A supply of easily available nitrogen is essential to the nutrition and the functioning of the organisms: usually there is insufficient in the straw so that a further supply is necessary and this becomes immobilised in the tissues of the organisms. The actual quantity immobilised depends on the reaction, being greater in alkaline than in neutral or acid conditions. Microbial protein is apparently a suitable source of nitrogen.

The Production of Ammonia from Peptone and its Oxidation by Bacteria.—The production of ammonia from peptone did not increase as the bacterial numbers increased, but beyond a certain point fell off. Introduction of a protozan Hartmanella lowered the bacterial numbers but seemed to increase the rate of ammonia production.

During the work on sugar beet effluent a number of organisms were discovered which oxidise ammonia to nitrite: critical examination has already revealed 42 distinct strains of these organisms instead of the five or six previously known. Four distinct species have been isolated from the Rothamsted soil which while agreeing physiologically with some of those from the filters are morphologically different.

The Plant in Disease.

Insect pests and their control. Insecticides.—Pyrethrum flowers contain substances highly poisonous to certain insects and quite harmless to plants and animals. Since pyrethrum is easily grown in this country there is the possibility that its cultivation may prove of considerable commercial interest. Dr. Tattersfield and his colleagues have studied the active principle: they find that the maximum yield is obtained when the flowers are fully opened, *i.e.*, when the disc florets are opening: the flowers should be harvested at this stage and not later, otherwise there is risk that the achenes, which contain most of the poisons, may be lost. Flowers differ considerably in ther pyrethrum content, however; the range has been from 0·4 to 2·0 per cent. A method has been worked out for determining the quantity in a single flower head and this can be used in plant breeding experiments to try and raise a strain of plants of high toxic value.

The Insect Pests.—In agriculture as distinct from horticulture a direct attack on the insect by sprays and other methods is not always possible, and for the insect pests of ordinary farms it is necessary to rely on some other means.

The natural control of insect pests is by their parasites and this is studied by Dr. Imms and Dr. Barnes. The Frit fly of oats is

usually parasitised to the extent of about 30 to 35 per cent., the range during the past four seasons has been 27 to 37 per cent. : parasitism becomes heavier as the season advances. There has been no severe attack during this period so that this degree of parasitisation is fairly effective as a control.

Willow midges during the last three years have also been well parasitised, the range being from 51 to 64 per cent., but foxtail midges have been more variable : there was 38 per cent. parasitism in 1928, only 3 per cent. in 1929 and 19 per cent. in 1930 ; it is not yet known why the parasities did so badly in 1929.

Immune varieties.—The simplest way of dealing with the Willow midges, however, is to grow varieties of willow immune to its attacks. Unfortunately, the most desirable commercial variety, *Salix triandra*, is susceptible, as are all its varieties. On the other hand, *S. purpurea, S. alba var. vitellina* ans *S. viminalis* and their varieties, also the cross *S. viminalis* × *S. purpurea* are immune. It should not be difficult to cross *S. triandra* with one of these immune varieties and so finally obtain a new variety, immune to the midge, but with the commercial value of the old *triandra.*

It remains to discover why some varieties are immune and others are not. There is evidence that the immune varieties contain a chemical substance which keeps off the midges : when an extract of an immune variety is painted on the susceptible varieties they cease to be so attractive. Further work is being done in the hope of discovering the substance and studying it in detail.

Problems of great biological interest, though not of obvious agricultural significance, are suggested by Dr. Barnes' discovery that the midge *Rhabdophaga heterobia* produces families of one sex only : some mothers producing males only and others females only. Apparently it is the mother, not the father, that determines the sex of the offspring. The investigation has necessitated breeding lines of pedigree male and female midges, studying and rearing their progeny for successive generations.

Bees.—In drawing up the programme of Bee Research the Department is assisted by a Committee of practical bee keepers who report from time to time the problems which are of special concern to them. In the main their difficulties arise from diseases which from the outset the Bee Research Staff were, by the terms of the grant, precluded from studying. In consequence the work has been confided to questions of management which are not only difficult, but completely lacking in interest to the non-technical person. The chief problem has been the study of the differences between the " warm way " and the " cold way " of arranging the frames in the hive : the warm way being one the in which the frames are placed parallel to the front so that the first frame acts as a kind of door shutting off the rest, while in the cold way the frames are placed at right angles to the front. The differences were only

slight, but by taking numerous observations continuously for several years certain conclusions have been reached.

(1) In *summer* the temperature inside the hive is almost entirely independent of the temperature outside, and completely independent in the brood chambers : the fanning by the worker bees being very effective.

(2) In *winter* the temperature inside is affected by that outside : it changes by 0·6° to 1° for each 1° change outside, and the change was greater in the "warm way" hives than in the "cold way" hives, especially on the north and east sides.

(3) In spring and winter the inside temperature seems to vary with the outside temperature.

A second question asked by the practical keepers was whether cane sugar or beet sugar is the more suitable winter food : there is a strong feeling in favour of cane sugar. Prolonged trials, however, failed to reveal any difference.

The work at present is concerned mainly with the study of brood food in relation to swarming and other activities of the bee.

Mycology.—The fundamental difficulty about the mycological work is that some of the most serious fungus pests are not sharply distinct and easily characterised, but are members of a large family each so much like others that they are distinguishable only with great difficulty, if at all, some of which, however, are almost harmless while others are very injurious. Dr. Brierley is investigating one of the most important fungi, *Botrytis cinerea*, of which he has already found over 200 strains, some of which are saprophytic, others parasitic on a limited range of plants, others again parasitic on almost anything. Even the parasitism, however, is not simple : it is easy to infect a plant with a strain which, under natural conditions, does not seem to attack it, and on the other hand a strain which in nature has virulently attacked a plant may fail to attack it in the experimental house. The various strains, the question of their permanence in relation to external and other conditions, and their relation to the host plant are being studied by Dr. Brierley, and the investigation is cast on such broad lines that the results are of wide biological significance for other phases of plant pathology.

Miss Glynne has developed a method of testing potatoes for immunity or susceptibility to wart diseases so that it is now even more sensitive than the ordinary field test, and it has the great advantage that it is rapid, needing only a few weeks, instead of the two or three years required for the field test. The practical question has arisen and needs settling : whether a variety in order to be classed as immune needs to pass the Glynne test in its most severe form, or in the milder form that corresponds in severity with ordinary field conditions.

The liability of a plant to disease is affected by the conditions in which it is grown : dressing with phosphate was found to reduce, and dressing with nitrogenous fertiliser to increase, the liability of

potatoes to the fungus *Corticium solani*: in practice, however, the position of the potatoes in the clamp is even more important.

Bacterial Diseases.—Mr. Stoughton is continuing the investigation on the angular leaf spot disease of cotton by *Bacterium malvacearum*. The disease organism may be carried on the seed coat and in the fuzz, but only rarely within the seed coat: it is killed by thorough disinfection of the exterior of the seed. If contaminated seed is not disinfected it produces diseased seedlings: the amount of infection, however, decreases as the soil temperature rises above 30°C. though infection still occurs at 40°C. Later on the plants grow out of the disease. They may, however, again become infected, and the progress of the disease is not affected by the soil temperature but by the air temperature being at a maximum between 30°C. and 35°C.

Virus Disease.—Dr. Henderson Smith is in charge of this work, aided by Drs. Caldwell, Hamilton and Sheffield.

Up to the present most of the work has as a matter of convenience been done with tomato plants: it has suffered from the disadvantage that the winter grown plants were very different from those of the summer—as is well known to all practical growers—and although they took the disease did so only slowly and with abnormal symptoms. The difference between summer and winter results has been traced to the difference in the hours of light: when the winter day was extended by five hours of good artificial light (from 4.30 p.m. to 9.30 p.m.) the summer disease symptoms were produced, and conversely when the summer day was shortened by cutting off the light the plants took the disease only slowly and abnormally, while in complete darkness the plants failed to take the disease at all.

Dr. Caldwell has shown that the virus cannot travel across dead tissue nor can it enter the living cells of the plant from the xylem unless some rupture has occurred. Where a leaf is inoculated the virus travels to the stem and then moves up and down at approximately the same rate.

Dr. Sheffield has studied the mode of formation of the intracellular inclusions found in cells of the diseased plants. Small particles carried in the streaming protoplasm coalesce to form larger masses and ultimately unite to form a spherical mass which becomes vacuolate and takes on the typical amoeboid appearance which caused them to be regarded at first as amoebae. The whole process has been photographed cinematographically and the film has attracted a good deal of attention.

The Farm.

During the year the farm and laboratories were visited by over 2,000 agricultural and scientific visitors, some of whom stayed for an extended period. Members of the staff gave over 79 lectures to farmers, students and others, these being arranged either by the County Organiser or by the National Farmers' Union in collaboration with the organiser or by a College or University.

2. NORTH OF SCOTLAND COLLEGE OF AGRICULTURE.

Research in Soils and Drainage.

During the year under review the Drainage work has been carried on as usual, but in view of the foundation of the Macaulay Institute for Research in Soils no successor was appointed to the late Mr. Newlands, Advisory Officer in Soils, and the section of the work formerly carried on by him has been largely in abeyance. A number of requests for help and advice in connection with soil and manuring questions were received from farmers and others and these were attended to by Professor Hendrick and his Staff.

Much field work has been done all over Europe and America on soil profiles, but there is a want of detailed laboratory work on the chemical composition and exact physical characteristics of the different layers found in soil profiles. Such exact work is required in order to check the conclusions which have been drawn from field observations. A research student, Mr. A. B. Stewart, has been engaged on such a detailed study of the composition and characteristics of Craibstone soil. His work, which will be published in due course, has not always confirmed the statements which have been made on the results of field observation.

A number of experiments have been carried out by the Mitscherlich pot method in Mitscherlich pots obtained from Germany, in order to gain experience of this method of testing soils, and in order to throw light on the failure of oats on certain soils and of clover on another soil. The failure of the oats had been ascribed in different cases to deficiency of nitrogen, to excess of lime, " lime burning," and to eelworms or other animals pests. The experiments show that it is not due to any of these causes, but is probably due to deficiency of available phosphate. In the case of the soil on which clover failed, a similar cause, deficiency of available phosphate was indicated.

The work of the Drain gauges has been continued on the usual lines. A paper was published in the Transactions of the Highland and Agricultural Society of Scotland giving a semi-popular account of the chief results obtained up to the present time, and especially the results obtained during the first six year rotation, 1921 to 1926 inclusive. An attempt is made to draw up a balance sheet of all that is put into and all that leaves the soil during this period. The general result is that losses of nitrogen and potash from the soil are small compared with the removal of these by the crop. In the case of nitrogen the drainage losses found are much less than they are generally supposed to be, and there is practically no loss from cropped and manured soil so long as the soil is covered with crop. In the case of phosphoric acid there is no loss in the drainage, but a considerable removal by the crop. In the case of lime on the other hand much more is removed in drainage than in crops. Moderate

manuring returns to the soil as much phosphoric acid but not nearly as much nitrogen and potash as are removed by heavy crops such as were obtained on the drain gauges.

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3. MACAULAY INSTITUTE FOR SOIL RESEARCH.

The establishment of a Soils Research Institute for Scotland has been made possible through the generous gifts of Mr. T. B. Macaulay, of Montreal.

Mr. Macaulay's ancestors came from the island of Lewis, and with a view to improving the agriculture and general living conditions on that island, he sought the co-operation of the Department of Agriculture for Scotland, through Sir Robert Greig. As practically the whole of Lewis is covered with an acid type of peat, and as there was very little information available in Britain on the best methods of dealing with this peat land, Dr. W. G. Ogg and Mr. W. G. Coles were sent to the Continent to prepare a report on modern methods of peat reclamation. Sir Robert Greig submitted this report to Mr. Macaulay in November, 1928, and Mr. Macaulay decided to establish and endow a demonstration farm on peat land in Lewis, and to provide funds for soil research work on the mainland.

An area of 147 acres of peat land forming part of Arnish Moor, and situated about three miles from Stornoway, was selected as the site of the farm. It consists partly of shallow peat of the heath type, and partly of very wet moorland with deep peat. The development of the Macaulay Demonstration Farm on this typical Lewis peat bog has been described by Ogg and Macleod in the Scottish Journal of Agriculture. During the past year experiments have been laid down to try the effect of different amounts of lime and various grass seed mixtures. The results obtained indicated that it is possible to establish good pasture on this class of peat land. Small areas of potatoes, oats, mashlum, turnips and vegetables were also tried, and cows have been purchased with a view to forming a dairy herd.

Craigiebuckler House, on the outskirts of Aberdeen, has been purchased and is to be equipped as a soil research station. The property consists of a mansion house, cottages, greenhouses, large walled-in garden and nearly 50 acres of land. Together with the farm in Lewis, it constitutes the Macaulay Institute for Soil Research, and most of the soil work previously carried out at the Agricultural Colleges in Scotland will in future be undertaken by the new Institute. It is governed by a Joint Committee representing the Department of Agriculture for Scotland, the three Scottish Agricultural Colleges, and the University of Aberdeen.

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4. CHEMICAL (AND ANIMAL NUTRITION) DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

Soils and Fertilizers.—Reference was made in last year's report to an investigation into the liming problem in Northern Ireland. Records of yields and calcium content of the crops from limed and unlimed plots are being made and the experiment is being carried out at nine centres. A further potato manurial experiment on similar lines to that reported last year has been carried out. The results showed that no significant increase in yield was obtained when the proportion of nitrogen, phosphate and potash was varied from that of the standard fertilizer dressing recommended for potatoes in Northern Ireland.

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5. RESEARCH INSTITUTE OF PLANT PHYSIOLOGY, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

Effect of Manures on Barley.—The study of the effects of manurial deficiency on barley was extended on the physiological side by an investigation of the sugar content of the leaves of plants completely manured as compared with those in which the amount of nitrogen and phosphate was reduced to one-fifth, and potash reduced to one-ninth respectively. In each case the "deficiency series" received the other manurial constituents, except that in minimum, at the same rate as the control series. Reducing sugars as well as cane sugars were separately estimated by microchemical methods which were sufficiently delicate to enable work to be undertaken with single leaves. Analyses were made of each leaf in all the manurial series, the leaf being taken at the time at which it reached full growth. In this way the effects of manurial deficiency were ascertained throughout the life cycle, and comparisons between the series at each stage could be made. For the eighth and ninth leaves separate estimations were made on leaves taken from three separate plants similarly manured. By analysis of variance it was established beyond doubt that the effect of manurial differences on sugar production both for reducing and total sugars was significant and, further that the differences between the eighth and ninth leaf were also significant within the series receiving similar manures. The error of a single sugar determination was found to be 12·6 per cent. Application of the analysis of variance to the whole data showed again that the quantities of reducing and total sugars vary between different manurial series as well as in successive leaves within each series. The results for treatment and leaf number are both very significant statistically, the probability against the effect being due to chance being much greater than 100 : 1. Interesting differences in starch production were also consistently observed, the indications being that starch production accompanies deficiency

in nitrogen and phosphorus, whereas the controls and potash deficient plants contain much less or none. The manurings used were such as to give quite normal plants, and indeed for the first six weeks no external symptoms of manurial deficiency were present, in spite of the chemical differences observed.

Electro-culture Investigation.—The work on the action of an overhead electric discharge on the growth of crops was carried out in 1929 by means of pot-cultures, the results of which have confirmed those of previous years. They show that electrification has little effect on the *final* yield of total dry weight, but has a definite effect on grain yield, this effect being brought about by a reduction in the percentage of sterile flowers per ear. They show also that an intermediate period of application of the discharge is the best, application for the second six weeks of growth (E_2 series) being more advantageous than an application for the first six weeks, or an application for these two periods together. An important new fact has, however, been brought to light in the relationship of this effect to manuring. With low nitrogenous manuring (in this case ordinary unmanured soil) the normal percentage of sterile flowers is very high and is not reduced by electrification, in fact it is possible that it may be slightly increased. The percentage of sterile flowers falls with increase of nitrogen, as the controls show, but with the sets exposed to the discharge there is a further reduction of sterility which in the E_2 series may be as much as 18 per cent. below the normal low level of the controls with the highest nitrogenous manuring. An additional effect has also been observed this year, namely the slight reduction in the amount of tillering produced by the discharge, and the increase in the rate of growth of the individual tillers, an increase which apparently only lasts a short time.

The Effect of Manuring on Grasses.—The work on the effect of manuring on the growth of grasses was continued. The experiment carried out in 1930 was planned to elucidate the effects of deficiency of nitrogen, phosphorus, and potash on the yield of grasses grown in competition with other species. Three species, Italian Rye, Cocksfoot and Rough-Stalked Meadow grass, were grown singly and in pairs in glazed pots, in sand culture, the procedure of the experiment being similar to that of 1929. In general it may be said that the grasses grown singly behaved very much as in 1929, although in a few instances marked differences were found, these being due presumably to seasonal variation. The main results of the competition experiment may be summarised as follows: (1) In no observed characteristic was Italian Rye affected significantly differently by the other species. Italian Rye germinated most rapidly and grew faster than the other two, which, in competition with it, made very poor growth. (2) Cocksfoot gave very marked differential responses to manuring and competitor in all observed characteristics; thus in tiller numbers the four manurial curves in competition with Rough-Stalked Meadow grass are widely

spaced, while in competition with Italian Rye the four curves are at a much lower level and superimposed. (3) Rough-Stalked Meadow grass was the most markedly affected by competition, and gave some very striking results when grown in competition with Italian Rye. Thus, after about the first nine weeks of growth the total top weight under a complete nutrient was actually lower than that under any type of deficiency, while all through the season it was very considerably lower than when grown under potash or phosphorus deficiency. The main reason appears to be that under a complete nutrient the Italian Rye forms a very heavy, thick growth, in which the Rough-Stalked Meadow grass is almost completely obscured, while under deficient conditions the Italian Rye forms a much more open community, giving its competitive species a much better chance to assimilate normally.

Effect of Air with Enhanced Concentrations of Carbon Dioxide.—The work on the effect on various plants of enriching the air with carbon dioxide was continued with tomatoes, an experiment which, as in 1929, was carried out at the Cheshunt Experimental Station by the kind permission of the Director. In 1929 an increase of fruit yield of 17 per cent. was obtained by the application of carbon dioxide derived from the combustion of oil, although it was clear that other products were also passing into the greenhouse. This year, accordingly, the technique was modified by the introduction of a water spray to wash the products of combustion before their entry into the house. The concentration in the glasshouse varied from 10·3 to 4·4 parts per 10,000 as against the normal 3 parts. The experimental plants showed a greater leaf area, and in counts of the number of trusses made on June 13th there was a smaller proportion of missed and poor trusses in the treated plants. Two maxima were found in the weekly quantities of fruit picked ; at the first maximum the experimental plants gave an increase of 29·3 per cent. over the controls. In the second period the plants treated with carbon dioxide showed no significant superiority, bringing down the total increase during the season to 13·9 per cent. Experiments carried out with tomato seedlings under the same conditions showed increases in dry weight in seven cases out of eight, four of these being significant.

Physiological Nature of Hybrid Vigour.—A study has been made of the phenomenon of the greater vigour often exhibited by the offspring of a first cross as compared with that of the parent plants. An investigation was undertaken of three strains of maize (obtained from the United States), a hybrid and the two parents. It was found that the hybrid does not differ in the least from its more vigorous parent as regards relative growth rate, nor does it differ from either of its parents as regards cell-size, photosynthetic efficiency of leaves, or the time of flattening of the sigmoid curve of growth. The only physiological differences observed were an increased percentage germination on the part of the hybrid, and

also a greater initial weight of the embryo, which gave an advantage which was maintained throughout the grand period of growth. The phenomenon of hybrid vigour is due to some process between fertilization and the setting of seed. After germination there is no real difference between the growth of the hybrid and that of the more vigorous parent. The results bring to light one other fact : that the relative growth rate is apparently inherited in the manner of a dominant Mendelian factor.

B.

PLANT BREEDING, CROP VARIETIES and SEEDS.

6. PLANT BREEDING INSTITUTE, CAMBRIDGE UNIVERSITY.

Wheat (R. H. Biffen, F. L. Engledow and A. E. Watkins.)—In wheat, selection work has been divided between a search for rust resistant types, a search for types showing resistance to what we have come to call the "wet-cold complex," and a study of the Rivet wheats. Progress in finding rust-resistant or wet-cold resistant types which are definitely better than types used in the past, is likely to be slow. In the case of Rivet, it is probable that all the more important types existing in the Eastern Counties have been selected, and next year a preliminary trial of 23 of them will be made. Interest in Rivet wheat among farmers appears to be growing and is likely to be stimulated by their experiences last year.

The long series of F_3 forms from crosses between White Fife, Yeoman II, Victor, etc., was harvested, about 30 per cent. of the families sown being finally retained. These will be continued as F_4 next year. Rust resistance, short straw, and adaptation to wet-cold land are the main features it is sought to embody in these hybrids.

A further series of interspecific crosses was made in order to test the possibility of introducing certain characteristics which appear of value into the bread wheats.

The investigations into inheritance and sterility in species crosses has now been completed as far as the broad principles are concerned and the economic possibilities of such crosses, as well as the methods most likely to be successful, are now fairly well understood.

The collection of wheat varieties, mainly from India and Persia, has been continued. So far those most likely to have value are the forms of *T. turgidum*, which may be useful in extending the use of the English Rivet wheat. Distribution of the strains to different parts of the Empire has been continued.

Barley (F. L. Engledow).—The survey of barley varieties on a wide basis is now practically complete. A considerable series of F_4 hybrids from inter-crosses among malting types is being continued. The future hybridising programme is still being deferred in order that more experience may be gained as to the probability of success from 6-row barleys. One such barley—B.224—is now definitely known to have good malting quality, and in the preliminary yield trials conducted by the National Institute of Agricultural Botany it has shown great promise. Another year of trials should put us in a position to decide on our future crossing programme.

Oats (H. Hunter).—The weather conditions of the season 1929–30 were such as to assist materially in the final selection of desirable forms of the Argentine × Grey Winter hybrids. Of the five seasons that the various derivatives of this cross have been under observa-

tion, the winter of 1928–29 was of a sufficiently severe character to test their winter-hardiness. In most of the summers there was sufficient rain and wind to provide an indication of a further important character, viz., strength of straw. In the past season, 1929–30, this was severely tested. Several selections exhibiting a marked superiority to Grey Winter came through this test very satisfactorily. Quality tests of the grain based on the determination of the percentage of husk have been made on the produce of many of the selections during the past four seasons. The final selection of forms for propagation on an extended scale has thus been made on a concurrent consideration of winter-hardiness, standing power of the straw, and quality of the grain. Quantities of seed of five selections sufficient to sow an initial propagation plot of approximately half-an-acre each have been handed over to the National Institute of Agricultural Botany by whom they will be placed on the market eventually.

Amongst the five new forms there are very considerable differences in the length and in the rigidity of the straw. With a view to further elucidating the association between the length and strength of straw, the quality of the grain and winter-hardiness, a series of new crosses was made in 1929. The produce of the F_1 plants raised therefrom in 1930 was sufficiently large to permit of husk determinations being made, and it will now be possible to follow the manner of segregation of characters, such as the quantity of husk, through succeeding generations in a connected manner. It is also hoped to make a concurrent study of the manner of association of this with other economic characters.

Reference has been made in previous reports to the efforts directed to securing earlier ripening forms for late ripening districts. In several cases a decided advance in the direction of earliness in ripening has been secured, but in every case this occurs in association with grain of inferior quality. The problem consequently now resolves itself into an effort to secure higher quality by the introduction of that character by crossing with a variety possessing high quality.

Spring Oats.—A series of selections obtained from the cross Black Potato × Victory was handed over to the National Institute of Agricultural Botany in the spring of 1930 with a view to their determining which are suitable for further propagation. In the case of this cross the basis of selection has been good standing straw and good quality of grain. Judged on the basis of strength of straw the whole series proved remarkably satisfactory, and those exhibiting good grain quality in addition have been adopted for extended propagation, and, it is hoped, distribution in the near future.

Peas (F. L. Engledow).—A further set of pure lines of existing varieties will be handed over to the N.I.A.B. for field trial. Hybrid forms, formerly many hundreds in number, have been reduced to

about twenty and next year for the first time small scale accurate trials of yield of these hybrids against existing commercial forms will be made.

Beans (H. Hunter).—The results of the extended cultivation of Bean No. 7 by the University Farm have corroborated the opinions formed during its earlier propagation. Fresh stocks of this line raised from single plants were grown in 1929–30, and their further propagation arranged for.

A series of various lines of spring beans selected on the basis of earliness in flowering and in ripening was grown in 1930. The produce of the most promising will be handed over to the National Institute of Agricultural Botany for observation in 1931, and with a view to obtaining their opinion of individual values before extended propagations are decided upon.

Sugar Beet (A. E. Watkins).—Some crosses have been made with sugar beet and the progeny are being examined.

Yield.—The investigations upon yield have taken two forms. First, the developmental influence of nitrogenous top dressings applied at different times has, for the third year, been the subject of widespread experiment. It was severely hindered by lodging and the consequent ear damage induced by a wet summer. Secondly, physiological aspects of development have also received further attention and good progress has been made in working out the stages of development of the ear of wheat. The results are extremely informative.

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7. WELSH PLANT BREEDING STATION, ABERYSTWYTH.

Wheat (T. J. Jenkin).—The selection work with Hen Gymro wheat may be said to be completed. The pure lines produced have been eagerly sought after by farmers. Henceforward only small plots of stock seed of each of the lines will be grown by the Station.

Wheat (Miss Kathleen Sampson).—Studies on the genetics of bunt resistance in wheat have yielded some interesting data, but confirmation and further experiments are needed for their elucidation.

Oats (E. T. Jones).

Pure Lines.—Three pure line strains of Ceirch Llwyd (*Avena strigosa*) and two of Ceirch-du-bach (*A. sativa* var.) are now available for distribution to hill farmers in Wales, and a leaflet dealing with the general features and economic properties of these lines is in course of preparation.

Genetics.—Studies in the inheritance of certain features of the oat grain are being continued. Data obtained relating to fatuoid and awn characters have now been published.

Economic Crosses.

White Winter Oats.—Seven segregate strains were tested against Grey Winter; compared with Grey Winter all the segregates gave superior yields of grain and about equal weights of straw. Three strains continued to justify their selection for multiplication and these are now under observation at the National Institute of Agricultural Botany. Some F_3 segregates resulting from intercrossing of selected white winter strains bred at the station show marked ability to withstand lodging.

Spring Oats.—Several strains of a cross Red Algerian × Victory continue to show promise in ability to resist lodging.

Segregates of Record × Radnorshire Sprig parentage bred for medium soil conditions are still in the yield trial stage.

Upland Oats.—A number of segregates of the cross *A. brevis* × *A. strigosa* were tested this season in rod row beds. Improvement in the type of grain has been obtained.

Oats (Miss Kathleen Sampson).—The investigation relative to the smut diseases of oats is being continued and an attempt is being made to follow the progress of the mycelium in susceptible and resistant hosts. It is evident that the fungus can enter and develop in the tissues of both types, but in those varieties which have been classified as "immune" the parasite makes slower progress after entry and fails to reach the primordia of the floral organs.

Cocksfoot Grass (R. G. Stapledon).—As the result of a special grant from the Empire Marketing Board, it has been possible to isolate a number of strains in greenhouses, and the results obtained have shown (*a*) that the houses give adequate protection against stray pollen, and (*b*) that very good crops of seed can be harvested. As the result of the same grant several of the earlier selections have now been grown on in Montgomeryshire, and in the case of strain 1,163 about 25 cwt. of seed in excellent condition was harvested from a five-acre field.

The breeding work is now concentrated on the production of a pure breeding strain of a certain hay type, and of pure breeding strains of four different pasture types.

Other Grasses (T. J. Jenkin).—Strains of timothy, perennial ryegrass and red fescue have been grown on in Montgomeryshire under the Empire Marketing Board scheme, and large scale sward trials will be sown down next spring with seeds mixtures consisting of these strains and of the cocksfoot.

By virtue of the co-operation that exists between the station and the Plant Research Station in New Zealand (Empire Marketing Board Grant) a number of New Zealand selections of perennial ryegrass are under study in comparison with the station's material—a general review of this aspect of the work has been published during the year.

The genetical work on perennial rye-grass is being continued, as is that on inter-specific and inter-generic crosses, and interesting results are emerging relative to fertility in the hybrid derivatives.

Other Grasses (B. L. Sethi—research student).—Studies are being undertaken relative to the chromosome numbers and breeding affinities of *Phleum*, *Festuca* and *Phalaris*.

Other Grasses (A. R. Beddows).—Assisted particularly by the grant from the Empire Marketing Board, a comprehensive research is being undertaken relative to the fertilization affinities of a large number of species of grasses, more particularly the annual species.

Legumes (R. D. Williams and R. A. Silow).

Genetics. Effect of Inbreeding.—Investigations on the effect of inbreeding on the vegetative vigour and fertility of the resulting families are being pursued. In red clover the reduction in vigour as measured by the productivity of the families from F_1 to F_2 generations is shown in the order of about 45 per cent., but it is interesting to note that two families have been bred which retain their vigour to a remarkable degree when inbred.

Various Characters.—In red clover a great deal of attention has been paid to such characters as longevity, earliness, leaf size, hairiness, flower and seed colour and leaf markings; while in white clover, leaf size, leaf markings and cyanophoric reactions are being intensively studied.

Economic Breeding.—The routine work in connection with the improvement of red clover, white clover, lucerne and birds-foot-trefoil has been continued and a large number of new crosses with fresh material have been made. Of the new strains produced, 15 red clovers of the late-flowering type and two white clovers are now being grown on at the farm and in the counties with a view to obtaining sufficient seed to carry out large scale field tests.

Seed Production (Gwilm Evans). In addition to the growing-on of pedigree strains, previously referred to, a scheme of trial has been initiated (Empire Marketing Board Grant) to test the suitability of various districts in Wales for producing seeds of pedigree grasses. With a view to this end, plots have been laid out in Cardigan, Brecon, Carmarthen, Glamorgan, Monmouth, Pembroke and Merioneth, in addition to those in Montgomery. Investigations are in progress to discover the proper technique of producing seed of leafy strain of grasses; the following problems are under consideration (*a*) Appropriate manures and time of manuring; (*b*) Broadcast *versus* drills; (*c*) The varying width of drills; (*d*) Nurse crop *versus* no nurse; (*e*) Effect of cutting aftermath on the next crop of seeds and (*f*) Methods of harvesting.

The results so far obtained of manurial treatments for seed production have varied considerably between the different species and strains; for example, a complete dressing of artificial manures doubled the yield of seed from cocksfoot, but the same dressing

reduced the yield of seed from red fescue to nearly one-third under similar conditions. All the trials so far conducted support the view that satisfactory yields of seed from leafy strains of grasses can be produced by the adoption of appropriate technique.

Plant Physiology (H. G. Chippindale).—With the aid of the grant from the Empire Marketing Board it has now been possible to commence physiological investigations on a number of problems that have been met with relative to the general investigations on grasses. Much attention is at present being given to the problems of delayed germination and delayed seedling growth, having regard particularly to their possible causation by seedlings of *Lolium italicum*. The results provide so far no evidence of delayed germination of *Festuca pratensis*, but there is an indication that it occurs with *Phleum pratense* and *Poa trivialis*. Seedlings of *Festuca pratensis* may be completely suppressed in growth by the presence of older plants of *Festuca pratensis* or of *Lolium italicum*, at the same time such seedlings are remarkably persistent.

Correlated with the above problem the reaction of the seeds of a number of species during germination to such physical factors as aeration, carbon-dioxide, concentration and acidity is under study.

It has been found that the seed of *Phleum pratense* and *Poa trivialis*, for example, react in a different degree to those of *Festuca pratensis* and *Lolium italicum* to poor aeration and increased acidity.

The germination of the seeds of different strains of grasses in solutions of cane sugar (*i.e.*, the measurement of "Saugkraft" as initiated by Zederbauer in Germany) has been under preliminary study with results that are sufficiently interesting to justify a continuance of the investigations.

Seed Mixture Experiments (W. E. J. Milton and T. E. Jones).—A large number of trials with simple seeds mixtures, including indigenous strains, are now in their third and fourth harvest years and are providing very valuable data. Under pasture conditions the indigenous strains in all cases showed a marked superiority over the commercial by the third harvest year and subsequently. An interesting result has been the excellent showing of indigenous cocksfoot on poor hill farms at high elevations, while it has been shown that in order to cover the ground properly it is necessary to sow wild white clover and appropriate bottom grasses on a fairly generous scale in mixtures consisting of indigenous strains of the larger grasses..

Tests of indigenous strains in pure plots under sheep grazing. (Ll. Iorwerth Jones and W. E. J. Milton).—Trials have been conducted with a view to improving the technique for employing sheep in investigations of this sort with the result that tethered sheep are largely replacing penning in the trials now in progress. An extensive trial which has now reached its fourth harvest year has

provided a large amount of information relative to palatability, persistency and yield, and will be reported upon during the present winter.

Pathology (Miss Kathleen Sampson).—Additional evidence relative to the systemic infection of *Festuca rubra* by *Epichloe typhina* has been obtained. Mycelium has now been traced in the rhizome, leaves, flowering stem, floral organs and the embryo of the mature seed. A new and simple technique for demonstrating the presence of mycelium in *Lolium temulentum* and *Lolium perenne* has been tested for the second season. The data support the view that these grasses occur either with or without the endophytic fungus.

Work in New Zealand (William Davies).—Mr. William Davies, on temporary loan to the Plant Research Station, New Zealand, has been co-operating with Mr. Bruce Levy in a detailed study of the strains of the rye-grasses met with in the pastures and grown for seed production in that Dominion, and work of a similar nature has been commenced with cocksfoot.

A preliminary account of the work has been published in the New Zealand Journal of Agriculture.

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8. SCOTTISH SOCIETY FOR RESEARCH IN PLANT BREEDING.

Cereals.

Oats.—Over ten thousand spaced plants representing many different crosses were grown under a cage for comparison and selection. Observations were made on the individual plants of several large F_2 families as regards inheritance of grain colour, and, from the examination of the data, it appears that certain black-grained varieties are genetically different in respect of grain colour. The search among the hybrids for economic types possessing stiff straw has revealed the presence of a number of promising forms, some of which are also early-ripening. Twenty-three fixed hybrid selections were grown along with certain standard named varieties in small field-trial plots for comparison. The plots were laid down in quadruplicate and in a manner suitable for statistical analysis of grain yields.

Varieties which in previous trials had given encouraging results were included in the Registration Trials carried out by the Department of Agriculture for Scotland, and also in several trials carried out under the supervision of the Scottish Agricultural Colleges. All the reports on this season's trials are not yet available, but from reports already received two varieties appear to be outstanding. One is the new variety now known as the "Elder" oat. This oat has strong straw, does not lodge readily and on fertile soils it gives a high yield of grain. It has now been registered as a new variety by the Department of Agriculture for Scotland. The

other variety has, for the last two years given encouraging results particularly in the North of Scotland ; it ripens early, possesses a good quality of straw, and does not " shake " readily.

Wheat.—Several F_2 families of wheat crosses were grown for observation and selection of the best winter-hardy types. A small collection of named varieties was also grown.

Barley.—A collection of named varieties was grown for observation.

Potatoes.

In the breeding work with potatoes a further series of F_1 hybrid families was grown for comparison and for selection of improved economic types, special attention being paid to the search for early maturing plants. Further observations were also made on the inheritance of various botanical characters in several F_1 and F_2 families. Almost all the families of seedlings were raised from parent plants which had shown no symptoms of virus disease. The results of breeding from healthy plants were encouraging.

The series of investigations being made for the purpose of noting the effects of repeated self-fertilisation in potatoes were further advanced. Several families have now reached the F_5 generation, and others are in the F_4 and F_3 generations.

The more promising economic seedlings in the propagated generations P_1, P_2, P_3, P_4, were compared in trial plots at the Plant Breeding Station, Corstorphine, and the best types marked for further trial. Healthy plants of all the selections were also grown at the Sub-Station to maintain healthy stocks, and, in addition, the more advanced seedlings were grown in larger plots to provide comparative data and seed tubers for future trials. As a result of previous trials six promising seedlings were sent in 1930 to the Department of Agriculture for Scotland for inclusion in their Registration Trials.

An endeavour is also being made to maintain healthy stocks of several named varieties at the Sub-Station, for use as parental types and as a source of healthy seed tubers.

Herbage Plants.

Further work on the genetical analyses of species populations has been undertaken, and a scheme for the classification of the units of less magnitude into ecological groups is being prepared. The plant forms in *Plantago maritima* L are being extensively studied in relation to this scheme, since they offer a good example of a species occurring in different habitats which extend over a large geographical area.

The study of *Phleum pratense* L, *Phleum alpinum* L, and their hybrids has been continued and significant results are being obtained. Dr. F. W. Sansome, John Innes Horticultural Institution, Merton, Surrey, has been collaborating in this work, and he has undertaken

the cytological examination of the hybrid material in which the chromosome numbers have been determined. An artificial hexaploid, the result of a cross between *Phleum pratense* (2n) and *Phleum alpinum* (4n) has been identified, and this plant has now been crossed with a natural *Phleum pratense* hexaploid plant. The hybrid plants are being grown for further cytological and genetical examination.

Three strains of pasture grasses have now reached their second year of vegetative multiplication. These comprise a strain of timothy, a strain of perennial ryegrass, and a strain of cocksfoot. Suitable methods for further multiplying these grasses by seed are now under examination.

Swedes and Turnips.

Methods of breeding continue to be investigated, especially with regard to the practicability of producing true-breeding strains of swedes by continued self-fertilisation under artificial isolation. The original selections for these strains are taken from heterogeneous commercial varieties or from segregations following varietal crossings.

Experiments are being continued to discover the mode of inheritance of various morphological characters and of resistance to finger-and-toe disease. Further investigations have been made to trace the origin of the "bulbless bolter," and for this purpose various forms of rape have been examined.

Promising lines of inbred swedes have been compared in yield trials in which estimations of total and soluble dry-matter contents were made. A number of seed-parent bulbs have been chosen from F_2 populations by means of similar tests; while the relative vigour of inbred and outbred strains (*i.e.*, their hybrids) has also been noted.

The results of the second stage of trials undertaken jointly by this Institute and the Chemistry Department, Edinburgh and East of Scotland College of Agriculture, have been collected and treated statistically, and are now under consideration. These trials were chiefly concerned with the value of the "Soluble Solids" test in breeding. The genetical and cytological relationships of the swede and turnip are being reconsidered in the light of recent knowledge. Mr. David G. Catcheside, Cytologist, Botany Department, The University, Glasgow, is co-operating in this investigation.

Virus Diseases of Potatoes.

As work on virus diseases of potatoes at the Society's Sub-Station, Gibston, Huntly, commenced only in the Spring of 1930, the investigations undertaken were mainly of a preliminary and general nature, the object being to provide material for a more detailed study in 1931. The investigations consisted of:—

(*a*) the raising of seedlings the parents of which, in 1929, were self-fertile seedlings infected with virus diseases;

(*b*) a preliminary study of the effect of virus diseases on the physiology of the host plant.

From the investigations under (*a*) data were obtained which

showed that progenies resulting from selfing disease parents were lacking in vigour and contained a large percentage of degenerate and virus-infected seedlings as compared with the progenies of healthy parents.

In addition to the above-mentioned work on virus diseases, seedlings of known parentage were raised and genetical data obtained on various botanical characteristics of each plant. The more promising seedlings were selected for further trial on account of their possible agronomic value. This work was carried out in conjunction with that at present in progress at the Society's Sub-Station at Ainville, Kirknewton, Midlothian.

Work on virus diseases of potatoes will also be in progress at the Plant Breeding Station, Corstorphine and at the sub-Station at Ainville, Kirknewton, in 1931.

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9. PLANT BREEDING DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

Oats.—(1) Improvement upon existing varieties: A new high-yielding, stiff-strawed type and a new early-maturing type for late districts have been introduced. These are under process of large-scale testing.

Continued selection has sifted out from various hybrid progenies a number of very promising high-tillering and white winter-hardy types.

(2) From the accumulated variety trial data, a preliminary survey has made possible the construction of a tentative oat variety-district map on which recommendations have been based with great success. The improved yields due directly to the substitution of suitable for unsuitable varieties in certain districts are quite remarkable.

Flax.—Stocks of two new varieties of proved merit are being bulked for *commercialisation* as rapidly as possible.

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10. NATIONAL INSTITUTE OF AGRICULTURAL BOTANY.

Crop Improvement Branch.

Yield and Quality Trials and Observation Plots.—The changes in the cereal varieties dealt with during the past year were more in the nature of additions than substitutions, for it is the usual policy of the Institute to carry on each set of trials for three seasons, and a new set began in 1928–29. On the other hand the first series of sugar beet trials, which dealt principally with the high-yielding

strains, came to an end in 1929, and in 1930 trials were begun with the high-sugar strains and were extended to two new districts, Cannington and the Fens.

The varieties under trial in 1929–30 were :—

Wheat.—Squarehead's Master, Chevalier, Steel (these three both normally and intensively manured), Setter, Ideal, Renown, Starling II, Fenland Wonder, Little Joss (two stocks) Wilhelmina (two stocks), three new stocks from the Cambridge Plant Breeding Institute and one from a private plant breeder.

Winter Oats.—A commercial stock, pure line, and a French stock of Grey Winter.

Winter Barley.—Carter's six-row, Plumage-Archer 1924, and a new variety from the Cambridge Plant Breeding Institute.

Spring Oats.—Abundance, Thousand Dollar (both normally and intensively manured), Golden Rain II and Star.

Spring Barley.—Plumage-Archer 1924 and Spratt-Archer (both normally and intensively manured).

Mangolds.—(*a*) Carter's Yellow Globe, Lord Warden and Golden Standwell, Garton's Large Orange Globe, E. Counties' Ipswich Globe and Cannell's New Century and Yellow Globe ; and (*b*) Webb's Red Intermediate, Johnson's Gatepost Yellow Intermediate, Cannell's Golden Gatepost, Garton's New Sugar and Kirsche's Ideal.

Swedes.—Sutton's Best of All, Cannell's Purple King, and Garton's Acme and Superlative.

Sugar Beet.—(*a*) Kleinwanzleben E, N and Z. Schreiber S.O., Strube Z, Hoerning R.R., Wohanka Z.R., Dippe W.I., Zapotil I. and Dobrovice ; (*b*) German-grown v. English-grown Kleinwanzleben E. ; (*c*) An "interference" trial between Marsters and Kleinwanzleben E. ; and (*d*) a trial in the Fens of Kleinwanzleben E, N and Z, Marsters, Kuhn P, and Johnson's Perfection.

Lucerne.—Strains of Provence, English, Grimm's, Kansas, Hungarian, South African, Hunter River (New South Wales) and Marlborough (New Zealand).

Peas.—Dun, Harrison's Glory, Prussian Blue, Koopman's Glory, Hijlkema's Unica and two new varieties from the Cambridge Plant Breeding Institute.

Vetches.—Swedish gore and a pure line gore from the Cambridge Plant Breeding Institute.

The trials in which the above varieties were included were in many cases repeated at all six of the Institute's trial stations. In some instances assistance was received from other centres ; for instance, Jealotts Hill and the Agricultural Institute, Kirton. Side by side with the plots was a wide range of single plots, which not

only served their usual purposes of providing early information about new varieties and demonstrating the merits of the best of the old ones, but also this season were designed in the case of sugar beet to afford material for the study of differential response of varieties to the date of lifting. The plots included 33 winter wheats, 8 winter oats, 8 winter barleys, 8 spring wheats, 33 spring oats, 12 spring barleys, 4 peas, 47 stocks of sugar beet, and some miscellaneous stocks including grasses, clovers, and fodder crops. Forty-five of these are either new varieties or re-selected stocks not yet on the market. Besides those described above almost as many plots again were grown at Cambridge to provide uniform seed for continuing the work in future seasons, as well as the usual reference collection of hundred of cereals. Finally the work was rounded off by sending samples for quality tests from all the wheat trials to the National Association of British and Irish Millers, from all the barley trials to the Institute of Brewing, and from all the sugar beet trials and observation plots to the Cambridge School of Agriculture.

It may be said of the results as a whole that, though no new variety which can as yet be definitely recommended has come to the fore, there are some of great promise among both cereals and roots ; and once again the trials have proved that negative results are as valuable as positive by bringing to light fatal defects in some widely advertised varieties.

Co-operation with Plant Breeders.—There has always been close co-operation between the Cambridge University Plant Breeding Institute and the Institute, but during the past year the relationship has been reviewed and steps taken by pooling resources to simplify the work of testing and introducing new varieties. One effect of the changes that have been made is that in future the Institute will be solely responsible for maintaining small stocks of seed of the numerous varieties of cereals which, though grown commercially, are often in demand for some special purpose. All requests for small samples of cereal seed should, therefore, be addressed in future to the Institute. The Institute is also now the sole channel through which the general public can obtain in the first instance stocks of varieties bred or selected by the Plant Breeding Institute. The latter tests on a small scale the many new varieties produced in the course of its work and then passes them on to the Institute for field trial at Cambridge and elsewhere. During the past year the number of cereals dealt with in this way was thirty-six, and there were also three varieties of peas.

The first effective steps in collaboration with the Welsh Plant Breeding Station were taken during the past season by the inclusion in the Institute's plots of four winter oats from the Welsh Station. Cordial conversations have proceeded as opportunity occurred throughout the year as the result of which the Station's experience with trials of grasses and clovers has been placed freely at the Institute's disposal, the number of varieties submitted for trial is

being increased, and most important of all the foundation of a working agreement for close co-operation in all subjects which are of common interest to the station and the Institute have been well and truly laid.

It is from independent effort that most improvements have come in the past, and the Institute attaches corresponding importance to support from private breeders. Two of the more promising varieties in the trials come from such sources. There is also a growing tendency for the leading seed firms to send their new varieties to the Institute for trial a year or two before they decide whether to put them on the market.

Co-operation with Farmers.—It is on the farms that varieties are put to the crucial test of a profit and loss account. All the more importance attaches to the records collected by Mr. J. B. Gill, Secretary of the Essex Farmers' Union, from his members. Records were received at the Institute from 886 fields in 1927, 622 for 1928, and 794 for 1929. Reports on the first two years have already been published and the final report is now being prepared. The records show among other things that the results obtained in the Institute's trials hold good in farm practice, that the two most remunerative varieties occupy less than 40 per cent. of the area under wheat, that the area under the best of the oats is even smaller, or again that those who cannot put a name to the seed they use fare much worse than their better-informed competitors.

This work has now been extended to Norfolk. Mr. J. F. Wright, Secretary of the Norfolk branch of the National Farmers' Union, is collecting particulars of the 1930 crops from his members, and it is hoped that with the support he is receiving from Mr. F. Rayns, the Director of the Norfolk Agricultural Station, he may be sure of a successful result.

Co-operation with other Organisers.—The Institute has for some years been steadily creating ties of common interest with one after another of the Agricultural Colleges and Institutes and the County Agricultural Organisers. The Director has this year visited every College, Institute and Agricultural Organiser in England with land at their disposal, and has established communications with the remainder. His proposals for the co-ordination of work with varieties hitherto carried on in isolation have everywhere met with a warm welcome and in 1931 there will begin the first scheme of variety trials to cover the whole country.

Seed Growing.—The policy of marketing annually small quantities of pure seed of the leading non-proprietary varieties of cereals began to bear fruit during the past season. Stocks of Thousand Dollar and Abundance oats were offered for sale during the winter, and Little Joss wheat during the past autumn. The seed met with a good demand in spite of being offered on a falling market. In view of the fact that the supply of good quality seed has been limited by bad harvest conditions, the Institute is offering small

quantities of sound yearling seed of Thousand Dollar and Abundance oats again this winter. It is intended to sell Squarehead's Master and Wilhelmina wheats, Grey Winter oats, and Spratt-Archer barley in the coming seasons. In all these cases the seed is sold to the trade only. The retail price for re-sale to farmers in the same season is fixed by the Institute, but the main purpose in offering these stocks is to provide merchants with high quality seed from which to build up a larger bulk for sale in the ordinary way to farmers in subsequent seasons.

Cereal Synonyms.—A Conference was held at the offices of the National Farmers' Union in January, 1930, to consider ways of preventing the use of synonymous names for varieties of cereals. The Royal Agricultural Society of England, the National Farmers' Union, the Agricultural Seed Trade Association, the National Association of Corn and Agricultural Merchants and the Institute all send delegates, and it was unanimously decided that each variety ought to be sold and grown under the original name given to it by the introducer, and that an expert Committee of six members should be appointed, one member from each of the Societies or Associations represented at the Conference and one from the Cambridge Plant Breeding Institute. This Committee has since been formed and steps have been taken to obtain the support of the various authorities who are concerned with the question, and to prepare a register of all distinct varieties of economic importance and their synonyms.

Official Seed Testing Station.

The Station received 23,477 samples in the twelve months ended 31st July, 1930. During the same period a further 3,110 samples were tested in connection with special investigations. The total of 26,587 was lower than in the two preceding seasons, but as the principal reduction occurred in the number of cereal and pulse samples the explanation is to be found in the unusually good conditions which prevailed at harvest in 1929. The contrary experience of 1930 is already having its effect, and the number of samples so far received in the present season is again on the rise.

A good deal of time has been spent in the past year in devising and bringing into use better methods for the storage and handling of samples ; the general lighting of the laboratories and offices has been more conveniently arranged ; experiments have been made with new kinds of Copenhagen tanks and with a small-scale water-softening plant ; a Hanovia Analytic Quartz lamp has been bought for experimental work particularly in the direction of the identification of rye-grass seed ; and the necessary apparatus has been installed to enable the Station to undertake moisture determinations on any class of seed.

The most important, however, of the new features in the Station's work has been its co-operation in the scheme arranged by the

National Farmers' Union and the Ministry of Agriculture and Fisheries for the inspection and certification of English wild white clover. The Station has received 571 samples of heads of clover taken by Inspectors of the Ministry from fields which the occupiers wish to have certified. These samples have been dried, threshed, and scarified to ensure even growth, and sown on land beside the Station with a view to examination in 1931 by the Committee of Inspection. At the same time the wide range of observation plots of clovers which have been so important a feature of the field work of the Station for some years past is being continued.

Other investigations have been energetically pursued. Peas have received very careful attention at the Station for some time, and during the past year a very successful study has been made in the laboratory and the field of the manner in which the position and extent of the burrow of the pea weevil affect the subsequent germination. Another subject of perennial importance is the distinction of normal from abnormal growths in germination tests. The Station is continually engaged in studying the value of abnormal defective and broken growths in all classes of seeds with a view to removing the possibility of discrepancies in reports. Work has also been in progress with lawn grass mixtures, the finer grasses and seed-borne diseases, and a very large number of tests has been made in the course of the investigation of loss of vitality in seeds under different conditions of storage.

The usual seed testing course and examination were held at Cambridge in June and July and were followed by a conference of seed analysts.

Potato Trials.

Yield and Maturity Trials of Potatoes.—In no year since the Potato Testing Station was opened at Ormskirk have so many different yield trials been in progress at one time. An elaborate study was undertaken of the effect of origin of the seed tubers on the crop and quality of three first-early varieties, Epicure, Ninetyfold and Arran Crest, and five of the later varieties, Majestic, Arran Banner, Arran Consul, Kerr's Pink and Great Scot. These trials included stocks drawn from Scotland, Lancashire, Lincolnshire, North Ireland, the Irish Free State and also from Dr. Salaman, Director of the Potato Virus Research Station, Cambridge. Ordinary yield trials were carried out at Ormskirk with Chisholm's Golden Wonder, commercial Golden Wonder and MacKelvie's 675, and at Kirton with Scottish and Lincolnshire once-grown seed of Incomer, Arran Banner, Great Scot, Majestic and British Queen. There were also early-bulking trials at Kirton, one of Arran Crest against Duke of York and the other of Herald, Sharpe's Express and Eclipse. It is interesting to note that Arran Crest and Arran Banner maintain the promise which won for them Lord Derby Gold Medals. There was only one entry for this year's Gold Medal trials, Glenshee, a heavy yielding

maincrop variety with white, oval to round, tubers, sent by Messrs. Alexander & Brown, of Perth. It was tested against Kerr's Pink in the usual way at Ormskirk and was awarded a certificate of merit.

Dr. L. H. Lampitt, Director of the research laboratories of Messrs. J. Lyons & Co., Ltd., has kindly undertaken to test systematically the quality of potatoes from the Institute's trials. This rounds off very satisfactorily the experimental work with potato varieties.

The Official Immunity Trials at Ormskirk.—The development of wart disease in the trial fields at Ormskirk this year was sporadic and in some respects puzzling. There is, however, no fear that a susceptible variety may slip through as immune simply from lack of infection. The Superintendent and his Assistant have always taken successful precautions to prevent such a mishap, and it is quite impossible since contact-inoculation and pot tests have come to reinforce the main field plots and the field check plots. The development of these time-saving laboratory methods has thrown a good deal of work on the staff, particularly during the winter.

In the field trials this year there were 153 plots. 48 of these were stocks entered for the first time, 32 were entered for the second time, 15 were stocks from the official Scottish and N. Irish stations, and there were also 8 miscellaneous stocks, 32 key plots and 18 controls. Last year all the distinct varieties were free from wart disease and this year all but three. Many of the entries are unlikely ever to reach the market, but there was a larger number than usual of promising varieties this year. There were also demonstration plots of varieties recently added by the Ministry to the list of approved immune varieties, the susceptibility trials, the usual comprehensive collection of commercial sorts, this year numbering 81, and a wide range of foreign varieties principally from Finland and Holland.

Potato Synonyms.—Potatoes are still the one crop in regard to which there is no sort of excuse for breeders, merchants, or farmers to remain in doubt about the identity of the varieties they are handling. Year by year the proportion of synonyms among the entries for the wart disease immunity trials at Ormskirk has been reduced. In 1920 it was 72 per cent.; this year the Potato Synonym Committee found that it had fallen to the lowest figure on record, 9 per cent. The Committee expect to find that some stocks entered in all good faith are indistinguishable from old varieties, for few individuals can be expected to know all existing varieties by sight; but it would be in everybody's interest if all raisers would be content to grow their stocks under numbers until they know that they are distinct and decide to put them on the market.

Thanks to the efforts of the Committee there are few if any of the larger growers who are deceived by synonyms. The synonym demonstration plots grown at Ormskirk, however, proved that there are still some firms who think it worth their while to exploit the

ignorance of the smaller growers, though the number of catalogues offering synonyms is definitely decreasing.

Virus Disease.—The Institute during the past year co-operated with the Potato Virus Research Station, Cambridge, on a wider scale than ever before by carrying out critical field trials of a number of Dr. Salaman's stocks not only at Ormskirk, but for the first time at three of the sub-stations, Good Easter, Cannington, and Newport. The Agricultural Institute, Kirton, the South-Eastern Agricultural College, Wye, and Seale-Hayne Agricultural College also lent their aid by growing trials or plots. In every case Dr. Salaman's stocks direct from Cambridge were tested against the best procurable Scottish stocks, and in a number of cases other stocks of the same varieties from Lincolnshire and N. Ireland.

Another particularly interesting piece of co-operative work in which the Institute played a considerable part was a study of the differential response of virus disease to environment. The work was suggested by the Ministry of Agriculture and the others concerned were Dr. F. T. Bennett of Armstrong College, Dr. Salaman and the Cumberland Seed Potato Growers Association. Seed tubers of Cumberland stocks of Great Scot and King Edward and Dr. Salaman's Great Scot were each divided into three sets and one set from each tuber was grown at Penrith, one at Ormskirk, and one at Cambridge.

The Institute's own staff have continued at Ormskirk their field trials of the resistance of stocks of six varieties from several districts to leaf-roll, and of different methods of maintaining healthy seed potatoes in England by rogueing. The season saw the conclusion of two investigations which have been in progress for several years, and reports on them are now in preparation.

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11. REGISTRATION STATION, DEPARTMENT OF AGRICULTURE FOR SCOTLAND.

Potatoes.

Laboratory Test for Immunity from Wart Disease.—The number of seedling potato varieties tested in the course of the year was 3,575. Of these 833 proved to be susceptible to the disease under this test.

Registration Scheme.—In 1930, 24 varieties were submitted for Registration test.

The number of varieties undergoing test for a second year was 16 and for a third year, two.

The Station participated in a test of the influence of manures on the period of ripening of the variety Golden Wonder. This test was arranged by the Field Trials Committee, Scottish Agricultural Research Council.

Virus Diseases Scheme.—Of the selections made previous to 1929, one bulked stock of Majestic occupied an acre plot in 1930. This stock qualified for a Stock Seed Certificate. A sample of 60 tubers planted at the Registration Station showed no evidence of virus infection.

Of the stocks remaining as isolated units in 1929 there remain six comprising 130 units which have satisfied the Department's inspectors in respect of their health standard. These are being bulked according to variety by their respective growers.

Of the units selected in 1929 there still remain under observation 51 stocks representing 12 varieties.

In 1930 additional farmers to the number of 20 entered the scheme and these along with those already participating offered 56 additional stocks of 20 varieties for selection.

In view of the large number of units now under observation, selected samples only can be tested critically by grafting. The remaining samples of units are grown on early ground near Edinburgh and judged by eye only.

Oats.

Registration Scheme.—Of the five varieties which reached the final stage of registration in 1929 one variety, namely, Aa 612, submitted by the Scottish Society for Research in Plant Breeding, was registered by the Department as a distinct new variety. This variety has been named " Elder " Oat. It has exceptional standing capacity and is regarded as specially suitable for cultivation after rich lea.

Two of the varieties were submitted to continued test in 1930 in half acre plots in duplicate.

Four new varieties were included in the half acre test plots in 1930.

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12. CROP (AND ANIMAL HUSBANDRY) DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

Potatoes.—Many parts of Northern Ireland are climatically ideally suited for the production of " seed " potatoes and an experiment has been carried out during the year to determine the effect of the size of " seed " tuber planted on the relative yield of ware, seed and chats in the resulting crop. This experiment is a replication of one carried out in the preceding year and corroborates results obtained by other workers. A greater proportion of seed size tubers is obtained when large sets are planted. A report of these experiments has been prepared for publication.

Grass Silage.—The work on the utilization of surplus grass during the grazing season has been continued this year. A report has been prepared for publication, giving details with regard to the

total quantity of grass cut, together with the acreage, analysis of the green material and of the silage, a record of the quantities fed and the liveweight gains put on by the bullocks.

Reclamation of Bog.—The Division has co-operated with the proprietors in the reclamation of used up-bog. Some five acres of the bog were dug up, all tree stumps, etc., removed, a heavy dressing of pig manure dug in and a dressing of two tons of lime applied per acre during the winter. The land was planted with potatoes in the spring and different mixtures of artificial manures applied to different sections. Potatoes were planted primarily for seed and a very heavy crop of excellent quality (seed) obtained.

This work is being continued and a further eight acres is being reclaimed this winter.

Cost Accounts.—Full and detailed cost accounts are kept by the Division of all farm operations at the Research Farm at Hillsborough. Data is accumulating and has already proved of material use in the management of the farm, for some of the experiments being carried out and for teaching purposes.

C.

HORTICULTURE
and
GLASSHOUSE CROPS.

13. LONG ASHTON FRUIT RESEARCH STATION, BRISTOL UNIVERSITY.

FRUIT CULTURE.

I. Plant Nutrition.

(a) Rootstock Problems.

Trial plots of standard and bush apple trees, the former under both grass and arable conditions, on the selected layered rootstocks raised at the Station, are now well established and detailed records of growth and cropping are taken annually on the trees.

These trials are to be supplemented by others on a variety of soils and sites on commercial holdings in the West Midlands area and already a number of plots of this kind have been established in Somerset, Gloucestershire and Worcestershire.

Similar trials are also in progress in which graded seedling stocks of Hampshire Crabb are used instead of layered stocks, the object being to compare the measure of uniformity which can be attained by the two methods.

The trees in the plantation of apples on the various " Paradise " stocks have now reached the stage when it is no longer possible to collect the detailed records hitherto obtained. The trees, even on the stronger stocks, are passing into their cropping period. The records of growth, number of flower buds and fruits previously counted upon each tree are now being kept by a system of selective sampling and total crop count and weight. The method adopted is to select several typical shoots on each tree and in this way compute the tree performance.

The planting distance on this plot is such that the trees are now almost touching. This makes it necessary to adopt some form of culture to check the growth uniformly. This has been accomplished by sowing a grass cover crop in autumn 1929.

The installation of a fruit grading machine has made it possible to record the size grades of the produce of the trees on this plot.

(b) Factors Determining the Relation of Growth and Fruit Bud Formation.

The respective activities of root, shoot, and leaf are closely concerned with the process of fruit bud formation in apple trees. The following sections have direct bearing on this subject.

1. *Stock and Scion Relations.*—The growth relationships of scion and root-stock are under examination in experiments in which bench grafted apple trees are used. Varieties exhibiting wide variations in vigour such as Tetofsky, Whitney, White Alphington and Morgan Sweet are used as scions on seedling rootstocks.

Detailed growth measurements are being taken with a view to examining the influence of the various factors concerned on variability of growth in the nursery row.

It is well known that certain rootstocks can exert dwarfing effects on scions, but the converse case of stimulation of scion growth by the use of a vigorous rootstock is so far unproved on the evidence available. Further data are required : hence the earlier experiments carried out at this Station, which failed to show any evidence of stimulation, are being extended, using large numbers of trees. Malling Type IX is being used throughout as the scion variety and Malling Types II, IX and XII and miscellaneous seedlings as the rootstocks.

The nature and location of rootstock influence are questions of fundamental importance. It has been suggested that rootstock influence, as commonly observed in its effect on the growth of the scion, is largely due to the stem portion of the rootstock. To test this point, experiments are in progress in which the varieties Bramley's Seedling and Worcester Pearmain are double worked on seedling roots, intermediate stem pieces of Malling rootstock Types II, IX and XII being used. The behaviour of the trees through the nursery and plantation stages will be followed in detail.

2. *The Influence of the Top Bud on the Growth of the Scion.*—In American experiments it has been shown that the position of the top bud of the scion materially influences the " take " of the grafts and their subsequent growth. Experiments to test this point under English conditions are in progress in which 600 grafts are used. One half of the grafts are placed with the top bud of the scion in line with the callus union and the remainder so that this bud occupies a position at 180° to the callus union.

3. *The Annual Shoot Growth Curve of Apples.*—This investigation has been in abeyance during the year pending further progress being made in the studies on normal seasonal physiology outlined below.

4. *The Normal Seasonal Physiology of Fruit Trees.*—Attention at present is focussed on the periodicity in root growth of two vegetatively raised rootstocks Malling Type IX and Malling Type XIII. Examinations are being made at intervals of root growth of stocks planted in a specially constructed bed. By washing out the soil it is possible to see the root growth and compare the amount and type of growth being made. The observations at present cover only one growing season and are being continued.

5. *Biennial Bearing of Apples.*—Experiments on this subject have been continued along the lines mentioned in the last report. Results from the various treatments previously given will not be evidenced before 1931.

6. *Ringing and Clamping.*—In last year's report the effects of bark ringing on growth characters and fruit yields of apple trees of the variety Bramley's Seedling were described in some detail. Further trees have been ringed during the past season and results of a similar character have been obtained.

In connexion with these experiments, samples of leaves and stem portions of terminal shoots of ringed and unringed trees have been analysed and it has been found that the ringing operation has decreased the nitrogen content and increased the dry matter content of these portions.

Storage experiments carried out on the fruits from the trees showed that those from the ringed trees were susceptible to Bitter Pit in the Ordinary Temperature Store and to Internal Breakdown under Low Temperature conditions of storage.

7. *Tree Shaping and Pruning.*—Work on the tree shaping and pruning plot has been continued. The experiment is still in the early stage, but there is already some indication that the modified leader system of pruning encourages earlier bearing by allowing the development of the lower laterals.

In an experiment in which the pruning systems, " regulated " and " spur " pruning are compared, the former system has produced trees which bear much heavier crops than the latter, but the edible quality of the fruits of the latter is superior to that of the former. When subjected to storage at 1°C. the " spur " fruits have been more susceptible to breakdown than the " regulated " fruits and moreover, the former fruits have exhibited breakdown chiefly outside the core area, whereas the latter fruits have mostly shown typical " core flush."

8. *Cover Crops.*—In the " grass " and arable cultural experiment on apple trees, the grass areas each received a spring dressing of nitrate of soda of 5 cwts. per acre in 1930, no nitrogenous manures being applied to the arable areas. Despite these treatments the trees on the grass areas showed strong symptoms of nitrogen starvation throughout the season, whereas the growth and foliage on the arable areas suggested vigorous high nitrogen conditions.

The " grass" trees show much dwarfing in growth from this cultural treatment and the " grass " effect is evidenced to different degrees by the individual varieties on the plots.

(*c*) *Manurial Experiments.*

1. *Pot Experiments.*—The sand culture experiments on apples, gooseberries and black currants in which the effects of deficiencies of the major essential elements on fruit quality are under examination were continued.

The experiments on apples have shown that wide differences in susceptibility to phosphorus and magnesium starvation exist between the varieties Bramley's Seedling and Allington Pippin, the latter variety being the more susceptible in each case.

The technique used in these experiments is to be modified in view of the results obtained to date. It appears that Malling Type IX rootstock is not suited for such experiments owing to its heavy blossoming propensities, while it also seems that in this type of

experiment it is necessary to grow the trees for a few years in a fairly vigorous way, without fruiting, before applying drastic deficiency treatments.

A new series of trees of the variety Bramley's Seedling on Malling Type I rootstock will be substituted for the present Allington Pippin series and grown in this fashion.

The black currants and gooseberries have now served the purpose for which they were planted and are being discarded.

2. *Laboratory Work.*—The investigation on the composition of the leaves and shoots of the apple varieties Bramley's Seedling, Worcester Pearmain and Allington Pippin under deficiencies of nitrogen, potassium, phosphorus, calcium and magnesium respectively has been completed. The results support those obtained in the previous experiment with Stirling Castle in most respects and also show wide differences in varietal behaviour due to the deficiencies.

The composition of leaves, bark and wood of terminal shoots of the variety Worcester Pearmain on various rootstocks, growing under conditions of "no manure" and a "complete manure" on the Malling Station plots, is under examination for the second season. The results obtained on the previous season's samples showed that significant differences were produced by manurial treatment and by rootstock effect.

The investigation of the effects of soil conditions in the Pershore-Evesham area on the composition of leaves and terminal shoots of the gooseberry varieties Whinham's Industry and Careless has been completed. Differences due to "variety" and soil effects are evidenced in the composition of the plants.

3. *Field Experiments.*—Manurial experiments on the Research Station plots and on commercial holdings were continued.

The Station plots include the following :—

(i) Deficiency treatments and the use of dung on apples, black currants, gooseberries and strawberries.

(ii) A "time of manuring" experiment on apples.

(iii) A comparison of various manurial systems on strawberries.

The outstanding feature of all the experiments is the effects of potassium deficiency which is shown by all plants. No other deficiency is observable on inspecting the plots.

The excellent effect of dung on strawberries continues to be extremely marked.

In the experiments in the counties the results continue as outlined in previous reports.

(*d*) *Soil Moisture Experiments.*

The soil moisture experiments on apple trees referred to in the last report were continued.

During the year the original "wet" series were again grown under conditions near the soil saturation point. The old "dry" series

were divided into two groups, one half being grown as the "wet" series and the other near the 50 per cent. moisture holding capacity of the soil.

The object of the treatments was to determine how quickly the "droughted" trees would respond to different soil moisture treatments.

A similar experiment was carried out on gooseberries, variety Keepsake, the soil moisture treatments being 100 per cent. and 25 per cent. saturation respectively.

(e) *Leaf Scorch.*

Pot and Laboratory Experiments.

1. *Waterlogging Experiments.*—Differential waterlogging and no waterlogging treatments were carried out on gooseberry bushes and the resultant shoots will be analysed to confirm the results reported in the previous report.

2. *Rootstock and Scion Effects in Leaf Scorch on Apples.*—The apple trees referred to in last year's report will be ready to plant as sand cultures in the winter of 1931–32.

3. *Chemistry of Leaves, Stems and Fruits in cases of Leaf Scorch.*—The various lines of work mentioned in the last report have been further pursued and the results support those previously recorded.

Field Investigations.

4. *Investigations on the Relation between Soil Conditions and the Occurrence of Leaf Scorch.*—These have been continued.

5. *Field Experiments with Potash Manures and Lime in controlling Leaf Scorch.*—Potash manures continue to give striking effects at most centres. In some cases a period of five years has been required to produce useful commercial results.

Lime has not produced any favourable effects on gooseberries on an acid soil.

6. *Spraying Experiments with Sulphate of Potash.*—Further good results have been obtained on plum trees by spraying frequently with sulphate of potash during the season.

(f) *The Effects of Leaching with Cold Water on the Foliage of Fruit Plants.*

Work during the season has been confined to the examination of cases of apparent leaching which have occurred in the field during the wet weather which prevailed. Some cases of serious defoliation accompanied by blotching were observed and these are being further investigated to determine whether the effects are due merely to leaching or whether they are complicated by magnesium deficiency.

(g) *Lime-induced Chlorosis of Fruit Trees.*

Cover cropping continues to exercise beneficial effects on lime-induced chlorosis.

Laboratory work on the movement of substances in chlorotic plants is in abeyance.

(h) Nutritional Factors affecting Fruit Quality.

The factors under examination were outlined in the previous report. Definite effects have been provisionally assigned to each factor and in certain cases inter-relationships between factors have been shown. The results obtained to date have been summarised in a paper.

(i) Subsoiling Experiments.

During the year the effects of the subsoiling carried out in the previous year were observed. In the case of a hop yard upon the Old Red Sandstone formation the effects were evident in an increased foliage on the bines and more bines per stool. On the same farm a large block of young Victoria plums were showing marked improvement following the operation.

In the case of an area subsoiled in 1929 and planted with strawberries immediately following the operation, the plants on the subsoiled area in the spring of 1930 were adversely affected. It was evident during winter that on the subsoiled portion of the field the water was not running off the surface as it was on the rest of the plot. It is suspected that the poor plant of strawberries on the subsoiled portion was due to the soil wetness in winter due to the subsoiling. By autumn 1930, however, the plants on the subsoiled area had grown so well that they were equal to the others in the field notwithstanding the fact that the subsoiled area was the worst area in the field and strawberries had never been hitherto grown on it successfully.

II. Surveys of Fruit Soils.

Soil maps on a textural basis have been prepared for the Pershore, Evesham and Cheltenham fruit areas. These areas are now being resurveyed to construct series maps in view of the decision of the Soil Survey Conference of the Ministry of Agriculture and Fisheries to follow this method in the future.

III. Special Investigations on Soft Fruits.

Strawberries.

It has again not been possible to give detailed attention to strawberry problems, though the major lines of work have been continued as far as possible under the conditions.

(a) Strain Trials.—These have been continued. Special attention has been given to the building up of stocks from the superior strains, and good stocks of Royal Sovereign have been collected on the Station plots.

(b) Botanical Classification.—This work has been continued in connexion with new varieties.

(*c*) *Abnormal Forms of Strawberry Plants.*—The incidence of these pathological types continues to be followed in commercial areas. Special attention has been given to the form known as "sudden Wilt."

The control of the main forms is being demonstrated on a trial plot in the Cheddar Valley area in conjunction with the Horticultural Superintendent of the Somerset County Council.

(*d*) *Anatomical Investigations on the Roots and Crowns on the Strawberry Plant.*—This work is in abeyance.

(*e*) *Insect Pests, etc.*—(Sections VII, VIII, IX and XX this report).

(*f*) *Fungus Diseases.*—(Section XX this report).

(*g*) *"Red Plant" and "Cauliflower."*—The relationship between eelworm numbers and the moisture conditions in the soil and plant is still under investigation.

(*h*) *"Small Leaf" form produced by Red Spider.*—(*See* Section VIII this report).

Raspberries.

(*a*) The cropping trials of selected varieties have been continued and it is hoped to publish at an early date the results obtained over the last four years. The varieties Lloyd George, Baumforth A, Improved Beehive and Duke of Cornwall have given the highest yields in the trials.

(*b*) *Raspberry Diseases.*—(Section XIX this report).

Currants.

(*a*) *Nutritional Experiments on Black Currants.*—(Section I (*c*) this report).

(*b*) *Red Currant Classification.*—A preliminary basis of classification of red currant varieties has been established and it is hoped to publish the results of the investigations shortly.

(*c*) *Diseases of Black Currants.*—(Sections VI, VII and XX this report).

Gooseberries.

(*a*) *Classification.*—This work is being continued, but is not yet sufficiently advanced for publication.

(*b*) *Nutritional Experiments.*—(Section I (*c*) this report).

IV. Fruit Breeding.

The seedlings which have been raised at the Station during the past few years continue to come into bearing and steady progress has been made in the selection of promising sorts. Fruit has been obtained this year from about 300 individual apple seedlings, 60 pears and 70 plums. Promising varieties are being propagated and planted for more extensive trial.

The trial plantation of selected black currant seedling varieties bore its first crop in 1930. Several raspberry and blackberry seedlings are under observation.

Further stocks of strawberry seedlings selected for their vigour and resistance to strawberry aphis and mildew have been raised and planted out.

PESTS AND DISEASES AND THEIR CONTROL.

V. Reversion Disease of Black Currants.

Observations on the field plot were continued. It was observed on this plot in spring of 1930 that reversion could be detected even in the incipient stages by the distinctly paler foliage colour of the affected bushes.

VI. "Big Bud" of Black Currants.

Investigations relative to the connexion between "Big Bud" and "Reversion" disease have been continued on the plot referred to in Section VI.

Experiments on the control of "Big Bud" mite by particulate sulphur have been continued.

VII. Strawberry Aphis.

Work on this pest is in abeyance pending arrangements for experiments with "dusts."

VIII. Red Spider (*Tetranychus telarius*).

Observations continue to confirm the fact that this pest causes a "small leaf" type of plant.

IX. *Harpalus ruficornis* and other Species of Carabid Beetles attacking Strawberries.

Investigations relating to the life histories, bionomics and control of Carabid beetles were continued in the Cheddar strawberry area.

The various types of injury on strawberry plants associated with the beetles were produced experimentally under controlled conditions. Further data relating to breeding habits, food, overwintering, etc., were collected.

Methods of controlling the beetles in the field were tried, including "trapping" and the use of Whizzed Napthalene as a repellent. The results were again inconclusive, owing to the scarcity of beetles during the cropping season.

X. Control of Capsid Bugs.

Extensive field trials on the control of Capsid Bugs by winter washes were again carried out on apples and black currants.

The results obtained with the Long Ashton wash were more variable and generally not of the same outstandingly high order as

in the previous two years, probably due in part, at least, to the abnormally mild and wet character of the winter. Increased capsid damage on apples also appeared to result from changes in the habits of the insects, which continued to attack the fruits until very late in the season.

A new emulsifier, Agral W.B.S., was found to be as efficient as Agral W. B. for use in the Long Ashton two-solution wash, and is a cheaper product than Agral W.B.

A new wash, in which high B.P. neutral tar oil and heavy paraffin are used instead of the former substance only, controlled *Lygus pabulinus* on black currants, a pest over which the older wash had failed to exercise efficient control.

XI. Pear Midge (*Contarinia pyrivora*).

A new experiment on the use of calcium cyanide as a control of this pest has been laid down. Trials are to be extended in the coming year.

XII. The Control of *Byturus tomentosus* on Raspberry and Loganberry.

Field trials on a commercial scale were carried out on loganberries at four centres. The materials tested were two pyrethrum spray fluids and a pyrethrum dust. One of the spray fluids was of the two-solution type and the other of the one-solution type in which case it is only necessary to dilute the concentrate with water.

Excellent control of the beetle on loganberries was obtained with both washes, especially the two solution wash, but the dust failed to give a commercial control and adversely affected the quality of the fruits

The use of pyrethrum fluids of the kind tested can be recommended for commercial purposes when the price for such fluids becomes an economic one.

XIII. Woolly Aphis.

All attempts to control this pest in the Bristol Province by means of the parasite *Aphelinus mali* have failed owing to the parasite being unable to establish itself and no further work along this line is contemplated.

XIV. Pests on Nursery Stock.

No material was submitted for further experiments during the year.

XV Apple Sawfly (*Hoplocampa testudinea*).

Field trials on the control of this pest were carried out on several varieties of apples using nicotine and pyrethrum emulsion sprays at two stages—blossoming time and one week after blossoming.

The results in the case of nicotine were inconclusive and the pyrethrum sprays did not effect any measure of control.

XVI. Plum Die-back in Plums.

No new feature has arisen in the investigations on this subject. Trees of Victoria and Burbank are being worked on some stocks which appear to be resistant to Die-back troubles and experiments on high grafting have been commenced.

XVII. Die-back in Apples.

During the spring of 1930 several cases of sudden dying off of whole trees and large limbs were investigated. The deaths were associated with species of *Cytospora*, but in all cases the affected trees were located on soils liable to drought effects. Many of the trees made remarkable recoveries and the die-backs have been regarded as resulting primarily from the abnormal weather conditions of 1929.

XVIII. Die-back in Black Currants.

Die-back in black currants prevalent in the Bristol Province in 1930 have been found to be due to the fungus *Diaporthe perniciosa*.

XIX. Raspberry Diseases.

Rogueing measures as a means of controlling Mosaic in the raspberry trial plots have been continued and have proved effective to the present stage.

XX. Strawberry Diseases.

Experiments are in progress with a view to determining whether "red" plant disease can be transmitted by insects and other vectors.

A form of leaf spot prevalent in certain strawberry growing areas, which is distinct from the common leaf spot due to *Mycosphaerella fragariae* is caused by *Septoria fragariae*. This fungus also causes a serious blossom blight and spotting of the fruits.

XXI. Collar Rots.

The incidence of these rots is under observation and methods of control by means of soil fungicides are being investigated.

XXII. Fruit Rots of Apples and Pears.

A rot due to *Phytophthora syringae* was very prevalent in the 1929 apple and pear crops and has been investigated.

The spotting trouble of the apple Allington Pippin is also under examination. A *Fusarium* was found associated with the later stages.

XXIII. Plum Rust (*Puccinia pruni-spinosae*).

Attempts have been made to transmit plum rust from the plum to species of anemone as an alternative host, without success.

XXIV. Black Currant Rust (*Cronartium ribicola*).

In field experiments this rust was not controlled by applications of Bordeaux Mixture, Lime Sulphur or sulphur dusts applied at the stage when the fungus began to make its appearance.

XXV. Black Currant Leaf Spot (*Pseudopeziza ribes*).

A Lime Sulphur spray was compared with Bordeaux Mixture as a control measure and proved ineffective.

XXVI. American Gooseberry Mildew.

Field experiments were carried out on the use of sulphur and ammonium polysulphide to determine whether the disease could be controlled by two applications of these materials during April and July, respectively. Neither treatment provided a commercial control of the disease.

XXVII. Apple Scab.

(*a*) *Field Experiments.*—The Long Ashton plantations were left so free from scab following the spraying in 1928 and 1929 that spraying in 1930 was much reduced, and observations were made chiefly on costs and spray damage. Tests of spraying with guns against spraying with lances showed that the use of the former reduced the time required without adding to spray damage. A further trial of the mixture of aluminium sulphate with a lime-sulphur spray showed that this mixture reduced, but did not entirely obviate, sulphur injury to Lane's Prince Albert.

A detailed examination of the wood-infection phase in the life cycle of the scab fungus has been started, and the production of spores from the wood throughout the summer has been noted.

In the Province, four large-scale trials on commercial plantations were carried out, the chief aim being to determine the level of scab control which could be obtained by the application of two pre-blossom and one post-blossom spray. In three of these plantations scab attack had been very heavy in 1929. The deposition of spores on the unfolding leaves in the spring was followed and the results obtained indicated that scabbed wood, and not over-wintered leaves, formed the principal source of infection during the spring.

The results of the spraying trials are summarised below :—

Locality.	*Area Sprayed.* Acres.	*Percentage Scab-free Fruit. Variety and Results.* *Sprayed.*	%	*Unsprayed.*	%	*Remarks.*
Stawell ...	15	Cox	97	Cox ...	55	
		Worcester ...	98			
Marston Magna	1¼	Worcester ...	65	Worcester	37	First spraying too early.
Suckley ...	1	Worcester ...	84	Worcester	19	
Lyonshall ...	9	Worcester ...	91			
		Grieve ...	96			
		Lane ...	98			
Lyonshall ...	3	Worcester ...	63	Worcester	0	Trees over-crowded.
		Lane ...	86	Lane ...	29	

The general level of control is thus seen to be higher than that usually obtained when spraying is not commenced until the pink stage.

(*b*) *Factors affecting Resistance to Scab.*—This investigation, conducted during the past two years by a post-graduate research student, has been suspended in consequence of her acceptance of an appointment elsewhere. A paper embodying the results of the work over that period has been prepared for publication.

XXVIII. Apple Mildew.

Trials with washes and dusts have been continued. Of the spray fluids used, a mixture of ammonium polysulphide and Agral has been most successful. Trials with dusts have been inconclusive to date owing to the slight degree of infections of the fungus in the season subsequent to the dusting operations.

XXIX. Tar-Distillate Winter Washes.

Since the tar-oil wash previously devised at this Station did not effectively control Red Spider on tree fruits nor Capsid Bugs on black currants, experiments have been made on the use of a heavy paraffin wash for these purposes. This wash was found to control these pests but did not provide any measure of control over aphis or apple sucker.

A new wash was prepared, containing both the high-boiling neutral tar-oil and a high boiling paraffin oil of low iodine value, and tested on apples against Red Spider and on black currants against Capsid Bugs. The wash appeared to give control of Red Spider and of the other pests controlled by the older wash on apples and in addition exercised practically complete control of *Lygus* on the black-currants.

No damage resulted to the trees from the wash in the experiments.

Blast furnace tar is under investigation with a view to determining the possibility of preparing a winter wash from the material. This product is cheap and available in large quantities.

The material examined differs from the corresponding Gas Works tar in that it contains a notable amount of paraffin hydrocarbons. It thus appears possible that washes prepared from this substance may yield results similar to those obtained by the use of the tar oil-heavy paraffin wash.

XXX. Pyrethrum Products.

Pyrethrum washes continue to give satisfactory control of *Byturus tomentosus* on loganberries and raspberries and of the willow beetle but pyrethrum dusts were ineffective against the former pest (Section XIV), probably due to the rapid loss of toxic properties from such materials on exposure. The fluid failed to control apple sawfly.

Attempts have been made to improve the spray liquid. It is unnecessary to extract the active principles with light petroleum, and a satisfactory spray mixture can be made by finely grinding the Pyrethrum flowers in crude cotton seed oil.

A product has also been made by dissolving the active principles of the flowers together with the neutral potassium salt of a sulphonated oil in pine oil. The preparation is neutral in reaction, and is quite anhydrous and thus it is expected that it will retain its activity on keeping. It yields a good emulsion simply on dilution with water and effects a satisfactory " kill " of insects.

XXXI. *Inula helenium.*

The flowers of this plant have been found to be devoid of any product of value as an insecticide.

XXXII. The Fungicidal Action of Sulphur.

The results to date of the work in the various sections of this extensive investigation have been summarised in a paper read before the International Botanical Conference in August, which will be published in more extended form in due course. The most interesting developments during the year have been concerned with the identity of the reacting substance produced by the living plant and the nature of its interaction with sulphur, leading to the formation of hydrogen sulphide as an end-product.

XXXIII. New Fungicides.

Salicylanilide as a foliage spray has been found not to damage sulphur sensitive apple varieties and will be tested as a scab preventive.

Copper naphthenate was found to be ineffective against scab.

FRUIT PRESERVATION AND PRODUCTS.

XXXIV. The Chemistry of Apples.

The investigations on the effects of nutritional factors on the composition of fruits have been continued.

The contents of nitrogenous, carbohydrate and ash constituents are materially altered by various factors such as manuring, pruning, thinning, ringing, cultural practices, etc.

These factors also affect the storage properties in various ways.

Two new compounds have been isolated from apples, a phenolic substance, which has been named malol, and a crystalline phytosterol glucoside.

The water soluble acids are under examination.

XXXV. The Physiology of Fruits.

(*a*) *Effect of Nutritional Deficiencies on the Development of Fruits.*—The investigations on gooseberries relating to the effects of potassium deficiency are still in progress.

(*b*) *Effect of Position on the Cluster on Fruit Quality.*—Curves of growth do not indicate any definite difference in the growth of terminal and lateral fruits.

These two types of fruits exhibit definite morphological features by which they can be readily distinguished. They also show differences in taste, in susceptibility to rots and in rate of maturity in store.

(*c*) *Effect of Maturity, as indicated by Starch distribution, on development of Bitter Pit.*—Experiments have been commenced with a view to determining whether susceptibility to Bitter Pit can be correlated with the stage of maturity of the fruits.

It appears unlikely that much information regarding the stage of maturity of the apple can be obtained by the use of the starch method at the time of picking.

Starch disappearance from the apple is correlated with other indices of metabolism.

(*d*) *The Effect of Nutritional Factors on Maturity.*—The effects on maturity in the apple of grass and arable systems, of ringing and of potassium deficiency have been studied over one season. The data are inconclusive and the investigations are being continued.

(*e*) *The Development of the Apple on the Tree.*—The course of the development of the apple on the tree is being followed as a preliminary to examining the effects of nutritional factors on the growth of the fruit.

XXXVI. Cider Investigations.

(*a*) *Cider and Perry Competitions.*—These competitions were continued. There were 148 entries spread over 6 classes.

(*b*) *The Value of Canadian Apples for Cider Making.*—Samples of alcoholic and non-alcoholic ciders were made from nine varieties of apples from Nova Scotia. Three of these produced ciders of fairly pleasant characters, the remaining six yielding ciders similar to those from ordinary English culinary varieties. The tannin content of the fruits was low in all samples.

(*c*) *Ciders from blends of Culinary and Bittersweet Varieties.*—Ciders made from Bramley's Seedling and Dabineet in varying proportions showed that the best results were obtained when the Bittersweet formed one-half or more of the blend.

(*d*) *Germ-free Filtration of Cider.*—The Seitz E.K. filter has proved of great value for yielding germ-free ciders for bottling purposes.

Inoculation experiments on such ciders have shown that an adequate degree of natural conditioning without excess deposit can be obtained by the use of certain yeasts.

(*e*) *Cider Storage Trials.*—The effect of cold storage has been examined on ciders made from several varieties. The period of storage necessary to check the fermentation in bottled ciders to suitable extents is also under investigation.

(*f*) *The Use of the Centrifuge in the Clarification and Fermentation Control of Ciders.*—A Sharples super-centrifuge, working at 16,000 revolutions per minute, has been tested as a substitute for the filter for cider clarification and fermentation control. The centrifuge eliminated nearly all the yeast cells, and in most cases almost completely arrested further fermentation. The centrifuged products were superior in flavour to comparable filtered ciders, being softer and retaining the fruity flavours to a greater extent. So striking have been the results in this first season's trials, that it is evident that the centrifuge has considerable potentialities in the cider industry.

(*g*) *The Resistance of Metals to Ciders.*—Several "acid-resistant" metals have been tested in ciders. Certain of them show considerable resistance to the action of the juices, and may prove suitable to replace the less acid-resistant metals for parts of cider-making machines and appliances with which the juice comes into contact.

(*h*) *Influence of Sulphur Dioxide on Turbidity and Deposit in Perries.*—Since it has been noted that in certain cases of perries the characteristic milky turbidity and jelly-like deposits have been absent from liquors treated with Sulphur dioxide, the action of Sulphur dioxide and of Potassium metabisulphite in preventing these unsightly formations in perries is being investigated.

WILLOW CULTURE AND THE UTILISATION OF WILLOWS.

Variety Trial Plots.—Cuttings of 28 new varieties of willows, selected from seedlings raised at the Station, were planted on the land which was added to the willow beds in 1929. The rods from these varieties will be further tried on the Somerset County Willow Trial Beds, and ultimately distributed amongst willow growers.

Five hundred sets of each of two varieties of willows were obtained from the Argentine and planted. Growth has been poor, and neither variety has yet shown characters equal to those possessed by English varieties.

Willow Breeding.—Three varieties of *S. triandra* were successfully hybridised, but no seed was developed from attempted interspecies hybridisation of *S. triandra*, *S. viminalis*, *S. purpurea* and *S. alba*; the information gathered during the course of the experiment has given data which may lead to success in 1931.

Value of Sets taken in Acropetal Order.—The experiment reported in 1929 was continued. The results obtained at the end of the second season have shown that apical segments produce more prolific plants in weight yield of rods than basal segments.

Treatment of Willow Pests.

(*a*) *Insect.*—The work on the control of the willow beetle *Phyllodecta* was continued in collaboration with the Entomologist of the University of Bristol. Further information was obtained relative to the activities of this insect. Pyrethrum extract, nicotine, paraffin and lead arsenate preparations were applied to the willows on the Station's beds, and similar experiments were carried out on commercial beds in Somerset.

It was found that the most effective control can be obtained by the use of pyrethrum when the insect is in the larval stage of development.

(*b*) *Fungus.*—The rust of osier willows (*S. viminalis*) was found to have its alternate stage on *Larix europaea* and to be identical with *Melampsora Larici-caprearum*, while that on *S. triandra* was identified as *Melampsora amydolinae*, which has all spore stages on this host.

The Culture of S. alba, caerulea.—As the scarcity of suitable sets of the Cricket-bat willow affords scope for investigation on methods of their production, an experiment was started with this object in view. Sets of various ages and lengths were planted and established plants pollarded at varying heights. Records are being kept of the growths made in the several cases.

The Preparation for Sale of Salix purpurea.—It has been observed that the bark of rods of this variety, under certain conditions, impart a characteristic colour to the wood. Experiments have been undertaken with a view to controlling these conditions. As the species does not give a marketable " white " in the ordinary course of peeling, and its " buff " being pale, it may be possible to develop a process whereby its rods may be produced in a more acceptable colour.

INVESTIGATIONS ON THE FACTORS INFLUENCING THE STORAGE QUALITIES OF FRUITS CARRIED OUT WITH THE AID OF A GRANT FROM THE EMPIRE MARKETING FUND.

I. Pot Culture Experiments.

(*a*) *Deficiency Experiments.*—The sand culture experiments in which apples, gooseberries and black currants are grown under conditions of deficiencies of nitrogen, potassium, phosphorus, calcium and magnesium were continued.

In the apple experiments the deficiencies have produced drastic effects on the variety Allington Pippin, and the trees under certain

treatments are too weak to carry crops for storage experiments in the future.

It is also evident, in the light of experience gained in the storage experiments and in the growing of the trees, that certain changes in the technique of growing the trees are necessary to obtain crops of a character suitable for reliable storage experiments. Malling Type IX rootstock, on which the present sets of trees are worked, does not appear to be a suitable stock for sand culture work, and it will be necessary to grow trees for a few years before fruiting them, in order to obtain sufficiently large crops.

For these reasons, it is proposed to replace the present Allington trees by Bramley on Malling Type I rootstock, and to grow these for a suitable period before fruiting them.

The gooseberries and black currants have now served their purpose and will be discarded.

(*b*) *Soil Moisture Experiments.*—Work was continued on the " moist " and " dry " series of apple trees which are being used in an experiment to determine the effect of soil moisture on the development of Bitter Pit.

The range of moisture content of the soil used was determined from the previous season's data, and in 1930 the " dry " trees were grown under conditions of 50 per cent. and 100 per cent. soil moisture content to see how quickly the " droughted " trees would respond to changes of soil moisture.

These preliminary treatments have cleared the way for the beginning of critical soil moisture treatments in 1931.

II. Storage Experiments.

A very large programme of storage experiments was carried out during the season, in which many factors likely to influence storage qualities were examined. In the majority of cases, the samples under investigation were stored both in the Ordinary Temperature Store and in the Low Temperature Store at 1°C.

The subjects of investigation included the following :—

Rootstock Effects, Age of Tree, Manurial Treatments—especially in relation to nitrogenous and potassic manures, Cultural practices —special reference to grass and arable systems, pruning, thinning of fruits, bark ringing, size of crop, time of picking and size grading of the crop.

The effects of possible combinations of certain of these factors were also examined.

The more important of the results obtained are as follows :—

Rootstock Effects.—Rootstocks may produce large differences in storage quality under certain environmental conditions, but the effects under other conditions may be insignificant.

Age of Tree.—The effects of this factor are difficult to assess owing to the complexity of factors invariably concerned. Young

trees tend to influence storage properties in the same direction as intensive pruning, thinning of fruits, etc., and tend to yield fruits of poor keeping quality.

Manurial Treatments.—The results of manurial treatments depend on the amounts and characters of the manures applied, the nature of the soil, the special characters of the trees and their nutrient conditions before the manurial applications, and the general environmental complex to which the trees are subjected. These facts preclude the possibility of comprehensive generalisations.

Nitrogenous manuring in particular must be considered in relation to cultural treatment. Thus, nitrate of soda applied at the heavy rate of 5 cwts. per acre to trees growing under grass has frequently scarcely affected the keeping quality of apples.

The effects of potash manures have not been altogether consistent, but certain points require mention, viz.

Potash manuring in some cases has decreased the storage life at ordinary temperatures, but increased the keeping period in cold store. It has usually increased susceptibility to rots in both stores.

It has frequently changed the form of "breakdown"—i.e., has changed "Internal Breakdown" to "Core Flush." It has consistently increased the storage life of plums in cold store

It has reduced wilting in both stores.

Cultural Practices.—Grass conditions have produced fruits of the typically nitrogen starved type which are long keepers in both ordinary and cold stores. Cultivation is extremely potent in increasing the rate of breakdown in fruits.

Pruning Effects.—Pruning effects depend on seasonal influences, size of crop, etc.

Intensive pruning tends to produce fruits susceptible to "Internal Breakdown" rather than to "Core Flush."

Thinning of Fruits.—The effects of thinning are in the same direction as pruning effects.

Bark Ringing.—The effects of bark ringing are not consistent, but some form of premature breakdown may be expected from this practice in the year of the operation or so long as the effects of the "ringing" are clearly apparent on the quality of the fruits. "Bitterpit," "Scald" or "Internal Breakdown" may result from bark ringing. On the other hand, "ringing" has usually decreased susceptibility to rots.

Time of Picking.—Early picking has induced "Scald" in some cases.

Size Grading.—Large fruits tend to break down from "Internal Breakdown" rather than "Core Flush" and are more susceptible to rots than small fruits.

III. Chemical Investigations.

All samples of fruits which have been subjected to storage experiments have been examined chemically, the determinations usually made being Dry Matter, Total Nitrogen, Sugars, Acidity, Ash Content and Ash Constituents. An extremely large body of data has been amassed, and these will only be analysed in detail after a further season's results are to hand.

It can be stated that the various factors examined affect the chemical composition in certain ways, but the storage qualities cannot be foretold with certainty from the chemical features so far investigated.

IV. Physiological Investigations.

See Section XXXV. (p. 66).

14. EAST MALLING RESEARCH STATION.

I. POMOLOGY.

A. In Relation to Tree Fruits.

(a) Rootstock Investigations.

1. *Stocks for Apples.*—A very comprehensive report on the rootstock trials has been published.

Two further considerable crops have since been harvested, and the results indicate that the potentialities for heavy cropping exhibited by certain combinations of scion and rootstock are being maintained, whereas the bad cropping performance induced by such a stock as No. 5 is still obvious in all varieties which have been examined.

There are indications that the heavy cropping record of some of these trees is having a marked effect upon their vigour.

One plot containing Bramley's Seedling and Worcester Pearmain apples on representative rootstocks has been grassed down with a view to studying the effect of this treatment upon the trees.

2. *Stocks for Pears.*—The trials of a number of varieties of pear on quince stocks and on vegetatively raised pear stocks are being continued. In addition, several lesser known varieties of quince are being tested as rootstocks.

3. *Stocks for Plums.*—Two younger experimental plots, including five varieties of plum on a number of rootstocks, are already showing differences in their vigour.

It is interesting to note the large differences between the same variety on, for example, two varieties of St. Julien.

While such stocks as Myrobolan B and Common Plum are, on the whole, maintaining their reputation for vigour and dwarfingness respectively, markedly different effects of the same rootstocks with different varieties are becoming apparent.

The series of trees on their own roots included in this trial bears out the theory that their vigour as compared with worked trees is largely dependent on variety.

4. *Stocks for Peaches.*—Sets of trained trees of one variety, Hales' Early, on various rootstocks, have been planted out against a boarded fence with a view to testing the differences in growth and fruiting.

5. *Stocks for Cherries. Sweet Cherries* (*P. Avium*).—The susceptibility of sweet cherry scions worked on one particular stock to bacterial die-back has, in the past year, become very marked. Of 287 trees planted out in the winter of 1928–29, nine trees died during the succeeding summer and autumn ; six of these nine trees were worked on the stock in question, and all appeared to have died as a result of bacterial die-back. Considering that approxi-

mately equal numbers of trees on twelve or more different rootstocks were planted, this seems to be a fairly emphatic result.

The stock trial is as yet too young to have given any very definite indications in other directions.

Acid Cherries (*P. cerasus*).—An obscure disease or unhealthy condition has appeared amongst the older Morello trees, and is so far confined to trees on Mahaleb stocks ; two out of eight trees on these stocks have been removed, and two others are affected. It seems likely that the vigorous early growth and satisfactory fruiting of these trees will be counterbalanced by a short life.

(*b*) *Analysis of Rootstock Influence and the Reciprocal Effect of Scion upon Root.*

A report has been issued on the analysis of a large series of trees which were lifted last winter.

Since then, records of blossoming have been obtained upon a similar series of stem and root grafted trees. In both series the precocity of trees on No. VIII as compared with such a stock as No. VI is equally obvious.

(*c*) *Root Studies.*

1. *Excavations.*—Further progress has been made with the study of mature root systems with particular reference to the effect of rootstock and soil. Two eleven-year-old Lane's Prince Albert apple trees on rootstock Nos. I and II were excavated from very heavy clay at Wisboro' Green, Sussex. While the difficulty of working in this soil has limited the number of trees excavated, some definite information is now available concerning root performance in clay. This makes an interesting comparison with the performance of similar rootstocks already excavated from sand and loam. The comparatively shallow and restricted nature of the root development in the clay is very marked.

In connection with the Kent Fruit Soil Survey (*see* (*h*) on p. 75), a study was made of the root systems produced under manured and unmanured conditions in an eight-year-old mixed plantation on sandy soil at Wrotham Heath. Part of the plantation had been dressed with 50 loads of farmyard manure in the year of planting, and the bush and tree growth on this part were considerably greater than on the unmanured part.

A series of trees and interplanted bushes were excavated on each half of the plot, comprising in all five pear trees (Conference and Dr. Jules—three on Quince A and two on Pear stock), ten black currant bushes (Seabrook's), and four gooseberry bushes (Whitesmith).

In these excavations a further improvement in technique was introduced by which root weights were obtained in 50 cm. squares and three vertical divisions, besides root plans from which the root-system can be reconstructed. The pear and gooseberry root-systems have been reconstructed and photographed.

The large trees on the manured plot had a much larger root-system than the small trees on the unmanured plot, but an exact comparison of root position cannot be made until the records are fully analysed. On both plots gooseberry roots penetrated to a maximum depth of 7 ft. 9 ins. and black currants to 6 ft. The deepest pear root was more than 10 ft. 6 ins. below ground level.

2. *Observation of growing roots.*—A technique has been developed for the observation of growing roots by means of glass-sided observation chambers. It has been found possible to measure the growth of roots of apple stocks along the glass side of an observation box filled with soil or sand. The development of root hairs, suberization of cortex, formation of laterals and other phenomena can also be observed and photographed, and the period and amount of growth under different conditions studied. This opens up a new line of attack on root problems. Further work on these lines is in progress.

(*d*) *Double Working.*

Apples and Pears.—Further interesting effects of an intermediate scion on vigour and precocity have appeared in the last year both in apples and pears. Amongst pears, the intermediate seems in some cases to have caused an "off-year," with hardly any blossom, and also to have, in one case, hastened the opening of the blossom in the spring. The fruiting of the pears has been so irregular that it is not yet possible to say whether or how far it has been affected by the intermediate. Few trees have yet borne a really heavy crop.

(*e*) *Pruning Experiments.*

1. *Apples.*—As a result of a severe thinning of most of the formerly "unpruned" trees, interesting results on cropping and fruit size are appearing. The bulk of unmarketable small fruit has been at once greatly reduced. It is hoped to find out how much regular pruning is needed to maintain these results.

2. *Pears.*—The varieties of Pears which have been subjected to various degrees of pruning for the past six seasons again bore considerable crops of fruit.

The trees receiving little or no pruning have already shown a falling off in vigour and in quality of the fruit.

Differences in the susceptibility to scab between the various treatments was also observed.

(*f*) *Manuring of Apples.*

(1) *Potash.*—Owing presumably to the somewhat heavy summer rainfall of the past year, the effect of the potash manures has been much more striking than in the drought of the previous year. There are still, however, several trees on the potash treated plot which show severe leaf scorch.

(2) *General.*—The trial of Bramley's Seedling and Worcester Pearmain on several rootstocks, in which a comparison has been

made between balanced manuring and complete starvation has been continued for another year, and a report has been issued. During the next season, attempts will be made to remedy the deficiency on the starved plot by application of nitrogen and potash, separately, and in combination.

A large scale manurial trial is being planted this autumn in which nitrogen, potash and phosphates in all possible combinations will be applied to plots containing Cox's Orange Pippin and Beauty of Bath on representative rootstocks.

(*g*) *Fruit Breeding.*

(1) *Rootstocks.*—The work of raising new varieties of apple rootstocks, in collaboration with the John Innes Horticultural Institution has been proceeded with. A large number of seedlings, the progeny of crosses between the Malling series of Paradise apple rootstocks have been planted out for a preliminary nursery trial. Further crosses between the chief Paradise rootstocks and Northern Spy have been made during the past year and the material will be handed over to the Entomological section for infection tests in due course.

(2) *Scion Varieties.*—Further crosses have been made with the object of raising new varieties of apples of good quality and high colour. A number of seedlings, raised in 1929, have been worked on dwarfing and vigorous root-stocks and will be planted out to afford further preliminary evidence of the influence of rootstocks in hastening the blossoming of seedling apples. At the same time, preparations for a larger and more definite trial are going forward.

A number of crosses between varieties of pears have been made with the object of obtaining varieties of pears of high quality and extended season.

(3) *Small Fruits.*—A large number of seedlings from first crosses between the main varieties of black currants have been raised during the past season. These are required to supplement information already obtained as to the inheritance of characters. A paper dealing with the breeding behaviour of selfed families of the main varieties of black currants has now been published. As further data become available, a second part of this paper will be published. Seedlings from a number of crosses between black currant varieties and nearly related Ribes species have been raised.

The raising of material to provide an insight into the genetic constitution and interrelationship of the chief red currant varieties is being continued.

(*h*) *Fruit Soil Survey of Lower Greensand in Kent.*

During the second year of the Survey pomological records have been taken as far as possible on the farm to farm method, from West Peckham to Crockham Hill on the Hythe Beds, and thence returning eastwards on the Folkestone Sand from Sevenoaks to Bearsted. The fruit holdings in these districts are smaller and

more scattered than in the area between Sutton Valence and West Peckham.

The soil chemist working at the S.E.A. College, Wye, has continued the identification and location of the different soil series occurring within the area of the survey.

Correlative work has shown that while it is possible to describe the soil conditions which are usually detrimental to good tree performance, the influence of good or bad management may often mask the effect of variation in soil.

A remarkable case of difference in growth in a plantation of pears and bush fruit, said to be entirely due to manuring in the year of planting, was investigated by excavating the root systems of trees and bushes on the manured and unmanured parts of the field (*see* Root Studies (*c*) 1) (p. 73).

(*j*) *Walnuts.*

Experiments in various indoor and outdoor methods of propagation have been continued, and an article on the propagation of Walnuts was published in the Journal of the Royal Horticultural Society, Vol. LV, Part 2.

An exhibit dealing with the propagation of walnuts was staged at the Walnut Competition held in the Royal Horticultural Society's Hall in November, 1929. The possibility of multiplication by vegetative methods of outstandingly valuable walnut trees for timber is being explored.

(*k*) *Pyrethrum.*

A number of clone selections were grown and their flowers, after being dried, were sent to Harpenden to be tested for their comparative toxic value. Three out of the seven proved superior to the remainder. These trials are being continued.

B. In Relation to Bush Fruits.

(*a*) *Currants.*

The Variety Trials.—The first full crop from the variety trial, carried out in collaboration with the Royal Horticultural Society has been harvested this year.

The heavy cropping potentialities of Baldwin on this soil is again demonstrated. While Davison's Eight have produced a fair crop, the cropping of Boskoop and Taylor's has been very much poorer.

Certain Seedlings raised at this station are also being tested and, in two cases, crops equal to that of Baldwin have been obtained.

A further planting of Red Currants, raised from clone material has been planted, in order to test the cropping capabilities of the main commercial varieties.

(*b*) *Raspberries.*

Four years cropping records of the variety trial plot have given useful results, although certain varieties have been considerably affected by disease and other troubles. The cropping of some

varieties has pretty certainly been reduced by mosaic disease and probably in some cases by other diseases, whilst some varieties, which seem always to show symptoms of mosaic disease wherever they are grown, have, nevertheless, cropped well. There appear also to be significant differences in the cropping of those varieties which have been hardly affected by diseases.

Preparations for a further cropping trial are well under way, the material to consist of those varieties which are still obtainable free from mosaic disease. Some thirty varieties are now being propagated for this purpose.

A system has now been devised whereby varieties newly collected for trial are in the first instance planted out on a " quarantine plot " in a remote part of the Station Plantation. On this plot they are observed from a pathological point of view for a year and preliminary roguing of " mosaic stools " is carried out. At the end of the year selected cane is planted out on a special propagation plot, and a stock of mosaic free cane is raised for use in the trials. Further details of this plot will be found under the heading " Raspberry Mosaic " on page 82.

Manurial Trials on Lloyd George and Pyne's Royal raspberries have been continued for a further season. The former trial is proving very accurate in spite of a marked soil variation, and interesting indications are beginning to appear, both in the cropping and in the growth of new cane.

The Pyne's Royal have proved exceedingly variable, the growth of cane being very irregular and many stools have died out altogether. In spite of this, indications of a response to manuring are beginning to appear, and the trial will be continued for a further season.

(*c*) *Strawberries.*

Strain.—Another year's work has confirmed the impression that, other factors being equal, difference in " strain " is mainly a question of vigour of plant, depending not on the clone but on the environment of the plant.

Selection of Runners.—As in the question of strain, preliminary experiments show that vigour of runner is more important than selection from fruiting parents.

Time of Planting.—Three years' experiments confirm empirical findings as the desirability of planting as early in the season as moisture conditions of the ground allow, provided there is a reasonable expectation of rain to follow. Under our conditions, August planting has not been successful.

Deblossoming.—An experiment now in progress has shown that the deblossoming of strawberry plants greatly increases the runner production and slightly increases the size of the deblossomed plant. No figures are yet available as to the effects of deblossoming on fruit production.

Varieties and Rogue Plants.—A collection of some twenty of the main strawberry varieties has been established. A number of "Rogue Plants" found in commercial stocks have been collected and planted up for observation and description.

(*d*) *Root Studies.*

The excavation of some black-currant and gooseberry root-systems is reported under I A (*c*) 1 on p. 73.

Statistics and Records.

The appointment of an assistant in the Statistical Section has made it possible to complete the summaries of back records.

The labour-saving devices which have been adopted have proved, in the main, satisfactory, and have considerably lessened the labour of recording. A technique for sampling the blossom production of a tree has been successfully tried out.

The experiences in the art of planning and recording horticultural field experiments have led to the publication of two reports; and an extensive memorandum, to be published by the Imperial Bureau of Fruit Production, is nearing completion.

The great accuracy attained by applying modern methods of plot arrangement to standardized horticultural material is becoming yearly more apparent.

II. PHYSIOLOGY.

Vegetative Propagation.

Investigations on the influence of external conditions upon the rooting of hardwood cuttings have been continued. A preliminary experiment has indicated that improved rooting may be obtained by placing a layer of sphagnum moss below the sand in which the cuttings are planted; this experiment is being repeated this year. A repetition of the experiment with shelters has again failed to give satisfactory results; this year a different type of shelter will be tried.

An attempt is being made this season to improve rooting by altering the internal condition of the cutting. Knife edge rings were made in the bark of actively growing shoots, and cuttings were subsequently taken from these shoots, the basal cut being made exactly at the ring.

It is hoped in this way to induce an accumulation of food in the region of stem subsequently used as cutting, and to start the wound healing processes under optimum conditions.

The relative effect of ringing the shoot two months, two weeks and one week before making the cutting is being investigated.

Leaf Relation of Apple Trees.

This investigation is being continued. Next season an attempt will be made to get some measure of the relative amount of leaf

surface per unit length, and per unit weight of stem in the case of older trees of the principal scion varieties worked on the more important stocks.

Growth.

Stem Diameter and New Shoot Growth.—The results of this investigation have now been published ; they provide some indication of the manner in which the previously recorded differences between furnished and unfurnished stems after a season's growth are arrived at, and show how the differences in the progress of the downward "wave" of cambial activity from newly developing shoots are reflected in the girth of older stems.

Seasonal Course of Root and Shoot Development in Apple Stocks.—The results of this investigation, carried out last year, are being analysed and a larger scale experiment on the same lines has been started. A thousand unworked one-year-old trees of No. XIII were planted out last spring, and the course of development of the various organs during the first two years after planting is being followed by lifting samples of 50 at intervals of about five weeks, and determining the increments in weights of roots, shoots and leaves by taking their fresh and dry weights.

The Effect of Scion on Root.—The results of a quantitative morphological examination carried out in collaboration with the pomological section on some series of young trees lifted in 1927 have been published. The results indicate that the amount of fibre on small roots expressed as a percentage of the total root system decreases as the root system grows in size, and that the variety used as scion may influence the total amount of root formed by the stock, and thus indirectly alter the percentage of fibre.

The distinctive morphological features characteristic of the root-systems of the various stocks were not appreciably changed by the variety used as scion.

A further series of trees lifted in collaboration with the pomological department last winter included trees where the scion had been worked direct on to piece roots of stocks as well as others worked on rooted stems. The results have been published and indicate that, for the variety of scion and stock used, the root system of the stock retains its characteristic features, irrespective of scion variety or of the methods of working.

Excavation of Root Systems.—The results of these investigations carried out in collaboration with the pomological department, are being prepared for publication.

III. BIOCHEMISTRY.

1. *Stock Influence.*

Ash Analysis.—Heyrovsky's polarographic method for estimating minute amounts of metallic elements has been simplified ; it is hoped that this will soon be a routine method of analysis, applicable

to many of the 21 elements occurring in apple tree ash, and that spectographic methods will be applicable to the remainder.

Functions of Ash Constituents.—Modifications of the injection method have been worked out for testing the effects of the various elements in the ash on young rootstocks and worked trees. These methods have been used in preliminary experiments on the following compounds : potassium molybdate, lithium nitrate, sodium chloride, potassium chloride, magnesium chloride, copper chloride, silver nitrate, ammonium chloride, ammonium nitrate, potassium nitrate and potassium dihydrogen phosphate.

2. *Resistance of Different Rootstocks to Insect Attack.*
(Jointly with Entomological Section.)

Causes of Resistance to Woolly Aphis.—The aim of this work is laid in disentangling the genetical and other causes of resistance, and, if possible, to provide a rapid laboratory method for testing the susceptibility of new seedlings to replace the present time-consuming method.

The bark extracts of immune trees were introduced into susceptible ones, and *vice versa*. The trees were inoculated with woolly aphis in some experiments before treatment, and in others some days after treatment. No change in degree of susceptibility was detected in any of the trees so treated.

Several methods of feeding woolly aphides on artificial media in the laboratory have been tested ; of these, two appeared more hopeful than the rest. In the more fully worked out method the aphides were placed on 6 per cent. agar medium in a Petri dish. Insects so treated lived up to 30 days, whereas similar starved ones lived only 10 days. The second method was devised for cases in which only a few drops of liquid medium were available. A single drop of the liquid was hung on a membrane supported between two microscope glass rings. Both methods enabled detailed observations to be made with the binocular microscope of the mouth parts of the feeding insects under reasonably aseptic conditions ; the proboscis was frequently observed embedded in the medium. The few comparative tests so far made of bark extracts from immune and susceptible trees by these methods have shown no differences.

Preliminary tests have shown that the acid constituents of the bark vary from variety to variety ; these are being examined chemically to determine whether any are associated with resistance to woolly aphis attack.

IV. PLANT PATHOLOGY.

Mycology and Bacteriology.

1. *Crown-Gall.*

The Relative Susceptibility of Apple Stocks to Crown-Gall.—An experiment has been carried out to test, under controlled conditions, data obtained from examining naturally infected trees in the field.

The method adopted was to plant up, in pots, comparable series of young stocks and to inoculate them in spring from a pure culture of *Bacterium tumefacieus*, the results being tabulated the following winter. A preliminary experiment was carried out in 1929 on two varieties, viz., No. 7 (very susceptible under field conditions), and No. 1 (resistant in the field), a unit of 100 of each being used. The two varieties gave markedly different results ; for example 67 No. 7 stocks developed galls as against 37 No. 1 stocks

In 1930 a further experiment was started on a larger range of varieties, but the results are not yet available.

2. *Brown-Rot Diseases.*

Experiments have been carried out with *Sclerotinia cinerea* to ascertain the manner of infection of leafy shoots in plum trees. Leaves of young plum trees in pots were inoculated with conidia of the fungus growing in pure culture. It was found that infection of the leaves readily took place through wounds, but under the conditions of the experiments no infection occurred on leaves not injured.

3. *Effect of Rootstock on the Susceptibility of the Scion.*

Another year's detailed records of the incidence of Apple Scab and Apple Mildew on the leaves and fruits of Cox's Orange Pippin on the spraying trial plot have been made. The data have not yet been fully examined. Broadly speaking, however, it is evident that the more outstanding results obtained in previous years are being confirmed, and that there is again evidence that the rootstock influenced the degree of infection of this scion variety by both these diseases.

4. *The Pathology of the Raspberry and other Species of Rubus.*

A Form of Die-Back in the Lloyd George Raspberry.—Enquiries have been received this year from various parts of the country, relative to a serious dying out of canes and stools early in the season, particularly in the variety *Lloyd George.* The chief characteristic of this disease is a rotting at the crown, followed by the death of some or all of the roots. In most cases a species of *Fusarium* was present on the diseased roots and crowns. This fungus was isolated in pure culture, and experiments are in progress to test its parasitism.

Raspberry Cane Blight.—A further serious outbreak of this disease was investigated in 1930 on a farm at East Malling, the affected variety being *Reader's Perfection.* Experiments on methods of control were started on this plantation, and also on the plantation of the variety *Bath's Perfection,* noted in last year's Report. The fungus causing the disease has also been found on the variety *Lloyd George.*

Perithecia of a fungus closely conforming to the description of *Leptosphaeria Coniothyrium* were found on a raspberry cane in close association with pycnidia of *Coniothyrium Fuckelii,* which has been

proved by inoculation experiments to be the cause of the disease. Subsequently the same fungus was found on a cane received from the Midlands. Cultural and inoculation experiments to determine the relation between the two forms are in progress.

Raspberry Mosaic.—The analysis of symptoms by grafting methods has been continued. Field experiments have been planned to determine (*a*) the method of spread of infection in a commercially laid out plantation and the possibility of control by roguing, and (*b*) the possibility of raising and maintaining mosaic-free cane of well-known commercial varieties for propagating purposes. The first experiment has now been concluded, but the full results have not yet been collated. In the second experiment particular attention has been paid to the two varieties *Lloyd George* and *Baumforth Seedling B*. On the extensive plantings of these two varieties only four canes have shown mosaic symptoms throughout the season. The total yield of mosaic-free cane of these two varieties this year is 3,200 canes. A part of this material will be used for pot experiments, and the remainder will be distributed to certain growers and advisory officers in the county for the purpose of starting replicate propagation trials. The subsequent behaviour of the cane after its distribution and planting will be followed up.

A Disease of Blackberries.—A severe outbreak of a disease on a commercial plantation of blackberries was investigated early in the year. A species of *Septoria* was present on the dead canes. This fungus has been isolated and its parasitism is being tested. Observations suggested that the outbreak was largely due to the method adopted in training the bines and to the manurial treatment. Preliminary experiments in control, based on those data, have been made.

5. *Bacteriosis in Plum and Cherry Trees.*

Bacterial Shoot Wilt of Plum Trees.—A detailed study (by cultural and inoculation experiments extending over several years) has been made of an organism which causes a bacterial shoot wilt of plum trees. As, apparently, the organisms had not previously been described, the name *Pseudomonas prunicola* was proposed for it, and a full description of it has been prepared.

Bacterial Canker of Plum and Cherry Trees.—The organism causing this disease is being studied particularly for comparison with *Ps. prunicola*; the two are found to be different in certain cultural characters. Field experiments have been carried out on young plum trees to test the effect of the application of certain fertilisers on the intensity of infection; there was no significant difference in the number of trees cankered on the treated and on control plots.

6. *Walnut Bacterial Blight.*

Foliage from walnut trees in various localities has been examined to see whether there is any evidence of the presence of *Pseudomonas juglandis* on established trees in this country. As a result, bacterial

spots were found on leaves from a tree in Worcestershire and one in Kent. A yellow organism was isolated in each case. Cultural and inoculation tests are being applied to ascertain whether these organisms are identical with *Ps. juglandis*.

7. *Apple Spraying Field Trials.*

Field trials of various sprays for the control of Apple Scab and Apple Mildew have been continued. Observations during the past year have been concentrated on infection of the fruit, and large crops have been scab-graded. The figures are now available but they have not yet been classified. A special study has been made of fruit-drop and of fruit-russeting following the application of sprays. It is most noteworthy that the greatest russeting and cracking blemishes on Cox's Orange Pippin fruits occurred as a result of the *pink-bud* application. This severe injury was clearly noticeable before the fruits were picked.

8. *Apple Cracking and Branch Blister Disease.*

Efforts to establish the parasitism of a fungus isolated from russeted fruits and blistered twigs of apple were inconclusive in 1930. The russeting and blistering symptoms have been very widespread during the year. Certain data on the appearance of fruit russeting in relation to the application of spray fluids have collected, but they have not yet been analysed.

Fungi similar to that found on apple have now been isolated from blemished pear, quince and plum fruits, and cultural comparisons of these with a type culture of *Coniothecium chromatosporum* Corda are contemplated. Material is being prepared for a further series of inoculations.

9. *The Verticillium Disease of the Hop.*

An outbreak of this disease has occurred this year at Matfield, Kent. This is the third locality in this country where the disease has been found, the other two being Penshurst, Kent, and near Hereford. In each case severe damage has been caused, particularly at Matfield. Cultural studies of the parasite are being made and field data are being collected with a view to elaborating methods of control.

V. Entomology.

Spraying Trials against the Fruit Tree Red Spider.

(*a*) *Winter Washes.*—Further investigations in relation to the control of the Fruit Tree Red Spider of plum have been continued in the field. A caustic wash, four different preparations of white oil emulsions, a white oil emulsion combined with a tar-distillate, and a lubricating oil, of declared consistency, containing two per cent. oil, were tested.

All the sprays were applied at the strength of five per cent. during January, but none of the treatments proved to be sufficiently toxic to the eggs of this mite to justify their use on a larger scale.

(*b*) *Spring and Summer Washes.*—It has been established that a one per cent. lime-sulphur spray, applied approximately ten days after the blossom period, will control the Fruit Tree Red Spider which occurs on plums. This treatment does not reduce the crop or damage the trees in any way.

Two reports have been published during the year.

Resistance of Different Root-Stocks to Insect Attack.

The collection of layered apple stocks (raised from immune seedlings) which proved to be resistant to woolly aphis attack last season, have been tested again this year. All these seedlings maintained the immunity exhibited during 1929, in spite of continued inoculations made throughout the growing season.

Some hundred new seedlings, raised by the Pomological Section, have been tested to determine their resistance, if any, to woolly aphis attack. However, all the seedlings, including a number of "open pollinated" Northern Spy Seedlings proved to be susceptible to attack. A further batch of seedlings is being tested.

Apple Sawfly.—A further attempt to control the Apple Sawfly by means of a post-blossom spray has been continued in the field.

Two sprays, namely, a pyrethrum preparation and an arsenical spray were tested. Neither treatment gave a satisfactory measure of control upon the Apple Sawfly. It would appear that the value of an arsenical spray varies from season to season, since some three years ago encouraging results were obtained with this poisonous spray.

Control of Black Currant Gall Mites.

Big-Bud on Black Currants.—Field spraying trials were commenced this spring to determined whether it is possible to obtain a greater measure of control of big-bud, by means of a post-blossom non-scorching spray, to replace the lime-sulphur wash at present used. The results of this investigation are not yet available.

Gall Mites on Red Currants.—Experiments have been continued on a field scale to test the value of lime-sulphur as a means of control.

It has been established that the mite can be checked by the sulphur-spray provided the spray is applied at the correct season. Some of the more important varieties of red currants are not injured by the treatment.

Systematic Study of Various Acari.

(*a*) *Eriophyidae.*—A systematic study of this group has been continued and a new sub-species, namely *Eriophyes similis prunianus* subsp. N. of plum has been described.

(*b*) *Tetranychidae and Tarsonemidae.*—The above, together with other species of Mites, have been investigated systematically and, from an economic standpoint, with a view to developing methods of control.

Apple Blossom Weevil.

Experiments to test the value of corrugated cardboard bands, and carpet felt bands, as a means of trapping this pest have been carried out in the field.

It has been demonstrated that both these types of traps catch more weevils than the ordinary " sack band " traps. In addition they are easier to manipulate in the orchard.

Two reports have been published during the year.

The Strawberry Tarsonemid.

Some aspects of the life-cycle of this mite have been worked out.

Records of its occurrence in this country show that it is established in many parts of Britain.

Certain varieties of strawberry are more subject to attack than others.

It has been proved by experiment that the mite may cause considerable damage to strawberry plants by feeding on the undeveloped leaflets, causing them to grow in a distorted manner, and producing the typical leaf " crinkle " so common in some varieties.

Preliminary investigations upon the control of this mite have been carried out both in the laboratory and in the field. The more promising treatments, *i.e.*, dipping of plants in lime-sulphur and fumigating the runners before planting, will be tested again next year.

Raspberry and Loganberry Beetle (*Byturus tomentosus*).

Further observations have been made on the life-history of this pest. In a small scale spraying trial carried out in the summer of 1930 the infestation was considerably reduced in the first four pickings by two sprayings of a new proprietary Pyrethrum extract, but the amount of reduction in the fifth and sixth pickings was insufficient. The proprietary Derris Root preparation used in previous trials without conclusive results was again used and showed considerable promise. Further trials are being planned on a statistical basis. An account of the work to date will appear in the station's annual report.

Insect Transmission of Raspberry Mosaic.

This work has been continued. The search for likely insect vectors has been narrowed down by observations on the method of spread of the disease. The possibility of certain insects (notably Jassidae) acting as vectors can probably now be eliminated. An outside infection experiment, not previously feasible, has now been planned.

Other Raspberry Pests.

These have been studied as far as opportunities have permitted.

Capsidae.

The systematic study of this group has been continued. A winter spraying trial against the Apple Capsid (*Plesiocoris rugicollis* Fall.) has been planned.

VI. Hops.

Cultural Trials.—The new Training and Distance Trial has had the crop recorded for the first time. The variations in the yield per acre due to the different distances apart of the hills have proved significant. The effect of the numbers of bines trained up each string has not been apparent this season, due, probably, to the fact that the hills are not yet fully established and consequently all were rather short of bine.

New Seedlings.—Many of Professor Salmon's earlier seedlings, which have had crop records and resin analyses taken over a period of several years and have proved not worthy of retention have been grubbed, their place being taken by new seedlings of greater promise.

Brewing trials are being continued with the most promising new varieties. Of the early varieties, six seedlings cropped at the rate of over a ton to the acre, and three proved richer than the Bramling. Among the mid-season hops, twelve yielded over a ton per acre, and six were richer than the highest commercial variety (Fuggles). In the late hops, thirty-six cropped at the rate of a ton per acre or over, and fourteen exceeded the richest commercial variety (Canterbury Golding).

Two New Varieties proved of greater preservative value than the richest hops obtainable in 1929; one of these (C9a) also exceeded the richest hops in 1928.

Incidence and Control of Downy Mildew.—The attack of the "spike" form of the disease in the Spring and early Summer was less severe than in the two previous seasons.

No "spikes" were found after the end of June compared with June 6th in 1929, and July 10th in 1928.

At the time of picking, many of the New Varieties that had not been sprayed with Bordeaux Mixture were attacked on the cones, some so severely that the crop was not picked. None of the commercial varieties were seriously attacked on the cones.

The seedling variety Y90 was sprayed with Bordeaux Mixture five times when in burr to injure the "brush" and so obtain seedless hops, and was entirely free from Downy Mildew on the cones, whilst the cones of the unsprayed hills of the same variety were completely destroyed by the disease.

VII. Empire Marketing Board Fund.

The work described above in connection with the root excavations, both from the pomological and physiological aspects, the biochemical investigations, the raspberry disease research, statistical studies, and much of the entomological research, have all been very greatly assisted by grants from the Empire Marketing Board. Moreover, the yearly raising of a large quantity of clone rootstock material for horticultural experiments in all parts of the Empire is made possible owing to contributions from the same source. Lastly, thanks to the Empire Marketing Board, a technical section

has now been set up to deal especially with all outside contacts, and to organise a scheme for the accommodation at this station of a limited number of post-graduate students from various parts of the Empire.

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15. HORTICULTURAL RESEARCH STATION, CAMBRIDGE UNIVERSITY.

The following kinds of vegetables are at present under investigation at the Research Station: Broccoli (Roscoff types), Brussels sprouts, Cauliflower, Onions (for spring sowing), Parsnips and Garden Peas. Work has also been commenced on Spring Cabbage and Lettuce, and is under consideration in the case of Celery and Canning Peas.

It is proposed to utilise the glasshouse formerly used by Mr. Brooks for research on Silver Leaf disease for continuing the apple and strawberry breeding already in progress, as well as for vegetable work.

On account of the large number of crops now being dealt with, it has become impossible, except in a few cases, to keep such records as would be necessary for statistically significant genetical experiments: work therefore tends to be on broad plant-breeding lines, and although results of economic value are being obtained, the carrying out of experiments of an academic nature is not feasible.

Lack of time and space will also involve considerable curtailment of the plan for co-operation with County Demonstration Stations referred to in the last Report. It will not be possible at present to increase the list of counties for which work is already being done. Personal attention is required if such work is to be worth while.

In view of the decreasing importance of the onion crop in this country, it is proposed to cut down the work on this vegetable. The requirements of market-growers in the way of spring sown onions are known, and with the material at present on the Station it is hoped that these needs will be met. On the other hand, Brussels Sprouts, Cauliflower, Spring Cabbage, and possibly Celery are of great and increasing importance; special attention will therefore be given to them.

The new glasshouse at the Research Station has facilitated work to a very great extent, and it has been possible to carry out effectively many operations such as cross-pollinating Broccoli, Brussels Sprouts, Onions, and Strawberries, which could not have been done so effectively in the open.

Trials.—Stocks of Broccoli supposed to be of the Roscoff type were tried at the Research Station during the winter 1929-30, and a further trial has been planted this year.

All stocks proved to be extremely mixed and several of them contained very few typical plants. Cabbage and Kale hybrids were present, also hybrids resulting from crosses with other types of broccoli (particularly with the Cornish type).

Stocks grown from seed saved in Penzance were a complete failure; most of the plants rotted away before the spring and few of the survivors produced a marketable curd.

As far as can be judged from experience at Cambridge, the nearer the plants are to the true Roscoff type, the more unhealthy they appear, with the exception of isolated plants (from which an effort will be made to raise strains suitable for East Anglian conditions). One of the advantages claimed for the Roscoff type at Penzance is that it retains its leaves during the winter, whereas other types shed them; at Cambridge, however, Roscoff types shed their leaves, while other types retained them.

As a consequence of the apparent unsuitability of the Roscoff type to our conditions, seed raised at the Station will, during 1931, be tested in Dorsetshire, where the Roscoff type succeeds and where seed-growing is possible.

At Denham, further extensive trials of lettuce were carried out. A few stocks have been isolated which can be recommended for commercial use and which will supply material for breeding experiments designed to produce improved strains of this crop.

The trials of cauliflower at Denham, and of canning peas and celery at Kirton, are in their early stages. It can be said, however, that no commercial cauliflower tried at Denham was up to the standard of Cambridge stocks.

The celery trials at Kirton contained many stocks with 100 per cent. of bolters. It appears from these trials that certain American and Continental stocks of the Golden Plume and Early Blanching types are likely to be of value for the new method of marketing celery (washed, trimmed and packed in crates). It is proposed to utilise selected plants from these trials for breeding purposes.

Valuable information was obtained from the trials of canning peas at Kirton, but in view of the absence of really definite information as to the requirements of growers and canners, no programme of work has yet been drawn up.

Trials of commercial strains of early cauliflower, spring-sown onion, and Brussels sprouts, have been made at the Research Station. Only one stock of sprouts is likely to yield material which could be used for breeding purposes.

The commercial strains of early cauliflower were particularly disappointing. Here again only one stock produced any plants likely to be of use in our experiments.

Brussels Sprouts.—Since the majority of Brussels sprout plants tested at the Station have been either self-sterile or feebly self-fertile, the methods adopted for improving this crop have been different from those used in the case of the onion, which is usually

self-fertile. The following methods have been tried : (*a*) selection of especially good plants of the desired type flowered together in isolation, the seed of each plant saved and sown separately ; (*b*) crosses between two selected plants ; (3) selected plants of similar type from an F_1 culture flowered together in isolation (seed from each plant sown separately); (*d*) two selected plants of similar type from an F_1 culture crossed ; (*e*) plants of similar type resulting from the cross (*d*) again crossed ; (*f*) selection of plants resulting from the cross (*d*) flowered together in isolation. The result of methods (*e*) and (*f*) is not yet known. So far method (*d*) has given by far the best results.

It is possible that methods (*e*) and (*f*) will result in a decline of vigour. Parallel strains of different origin are, however, being built up to cross with the original strain should this decline of vigour take place.

A large amount of seed still remains untested, and it is probable that arrangements will have to be made with some grower for the trial of this seed.

Cauliflower.—All cauliflower plants tested so far have proved to be fully self-fertile and cultures raised from selfed plants have, in some cases, been segregated for the following characters : (*a*) size of plant, (*b*) period of maturity, and (*c*) leaf type. The segregation has, however, not been wide, which can be accounted for by the fact that great care was exercised in the choice of plants for breeding. A small plant selfed does not give large plants : the progeny vary from parental size to medium size. Nor does an early plant produce late-maturing progeny, though some of them may be a good deal later than the parent. Cultures apparently true for period of maturity and size of plant have been obtained.

In the progeny of one plant there occurred individuals with olive-green or " unwaxed " foliage. A similar type has been reported in the case of cabbage, and it occurs also in the onion. Tests with onions having this olive-green foliage show that the character is apparently a simple recessive.

Sufficient seed from selfed plants was available this year for a preliminary trial. This was so successful that an effort was made to obtain a further supply of seed from selected plants, although they had been planted out at so late a date that normally seed could not have been obtained from them outdoors. Fortunately, weather conditions were favourable, and it is probable that a fair quantity of seed will be obtained.

In the opinions of experts, some of the Cambridge stocks are likely to be suitable for pickling purposes. In view of the importance of the trade in pickling cauliflowers, and the difficulty growers find in supplying the picklers with the right type of curd, the problem of isolating strains suitable for pickling purposes will be kept in view.

Genetic experiments designed to throw light on the mode of inheritance of earliness and lateness in the progeny of a selfed plant

came to an abrupt end this year. In F_4 the plants had almost ceased to be cauliflowers, their curds being mostly small, leafy, green, and loose, and this fact precluded the possibility of exact observation. No " degeneration " of this sort had been noticed in F_3, though the curds were not equal to those produced by the F_2 generation. It may be noted that the F_3 plants were copiously self-fertile.

The experiment might be repeated at a later date when more space is available.

Lettuce.—Experiments which (it is hoped) will elucidate the mode of inheritance of a number of characters (most of them of economic interest such as earliness, colour of leaf, size of heart, solidity of heart, etc.) have been begun. The season has not, however, been favourable for the production of lettuce seed, and only a small quantity has been obtained from the crosses made.

Onion.—This year for the first time tested material has been available for genetic experiments and a number of crosses were made under glass. The characters dealt with were, white, " blood-red," yellow, dark salmon, pale salmon, oval, flat, waxed foliage (normal colour), unwaxed foliage (olive green). Sufficient seed was obtained to continue the experiments.

About 150 bulbs were self-pollinated under glass : 38 strains were flowered in muslin enclosures ; and 12 strains flowered in isolation. The fact that the viability of onion seed decreases very rapidly after two years necessitates more seed growing than is needed in the case of, say, Brussels sprouts, and therefore fresh seed has to be obtained at intervals of stocks which it is desired to retain. The objects of the rather numerous operations detailed above are (*a*) improvement of existing strains, (*b*) preservation of strains, (*c*) preservation of material necessary for genetic experiments, (*d*) production of seed in bulk for trials of strains likely to be useful commercially, (*e*) testing genetic constitution of material.

Parsnip.—Selection and the raising of progeny from individual plants (which, however, must be cross-pollinated) continues.

Last season the following facts were noted : (*a*) the progeny of selfed plants were deficient in vigour ; (*b*) intermediate shapes may have longs in their progeny ; (*c*) longs may throw intermediates. The intermediate selection now being worked on has apparently ceased to produce long shapes.

Space and time will not permit a full investigation of the mode of inheritance of shape characters at present.

Peas.—59 F_3 cultures were grown this year. The examination of them is not completed yet. The combination of characters for which the original cross was made occurred in the cultures. Many useful cultures were noted, but it will be impossible to preserve more than a few of them. A good deal of useful information was obtained, but it will not be feasible to pursue the experiment in full detail in the present circumstances.

Fruit.—Several seedling strawberries fruited this year, and among them were three of promise. These have been propagated. Further crosses have been made this year, one of the objects in view being the attainment of vigour allied with commercial utility.

A seedling damson was accepted by the Royal Horticultural Society for inclusion in the Ministry of Agriculture's trials of commercial fruits.

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16. EXPERIMENTAL AND RESEARCH STATION, CHESHUNT.

The activities of this Station are concerned mainly with glass house problems, and from year to year all phases of the industry come under investigation.

I. MANURIAL AND CROP MANAGEMENT TRIALS.

A. Tomatoes.

(*a*) *The substitution of wheat straw for stable manure.*—The substitution for stable manure of wheat straw has been tested during the past three years, and in all cases the crop has been improved. It is suggested that substitution can be made at intervals with good results, especially on heavy soils. The application of wheat straw in addition to stable manure also improved the crop, and growers are asked to conduct small experiments along similar lines to see if these results have a wide application.

(*b*) *Lime investigations.*—A lime experiment was started in two new houses in 1928. The soil on analysis proved to contain only the least traces of lime, and one house was limed, the other being left without lime. In 1928 and 1929 the unlimed house produced a heavier crop than that which received lime. In 1930 two plots in each house were limed and two left untreated. No evidence was obtained to suggest that liming increased the crop.

(*c*) *Watering experiments.*—The watering experiments were continued. Underground watering by means of buried pipes was beneficial, when continued only to the end of May. Later applications by this method caused water-logging of the lower layers of the soil and produced a yellowing of the foliage.

(*d*) *Nitrogenous fertilisers.*—Tomato house 3, where manurial experiments (series J) had been in progress since 1915, was resoiled. The old soil was removed to a depth of eighteen inches and replaced with turf soil taken from a meadow near Brimsdown. The house was divided into sixteen plots and used for testing four different forms of nitrogen, namely, sulphate of ammonia, nitrate of soda, and nitrate of lime, applied as top dressings, and cyanamide before planting. No difference in crop was noticed in the different plots, but this is not altogether surprising in view of the new soil.

In tomato house 4 (series K), six small plots were made at the north end as a permanent demonstration of the effect of (*a*) withholding manures entirely, and applying (*b*) complete artificials, (*c*) complete artificials with stable manure, (*d*) complete artificials without nitrogen, (*e*) without phosphate, and (*f*) without potash. The rest of the house was resoiled like house 3.

Plots were treated in duplicate with hoof and horn, Peruvian guano, shoddy, dried blood and fish meal. As in house 3, no striking differences were noticed.

(*e*) *Improvement of varieties.*—In 1929 many new crosses were prepared between Up-to-date, a poor cropping variety highly resistant to Leaf Mould (*Cladosporium fulvum*), and several of the best varieties. The F_1 generation and, in some cases, the F_2, were grown in the variety house this year. Results provided indications that good cropping varieties resistant to leaf mould will ultimately be obtained.

(*f*) *Temperature requirements.*—The investigations of the temperature requirements of the tomato were continued. The effect of ventilation on air temperature within a glasshouse and the effect of watering on soil temperature has been studied. Further, the rate at which the Station soil cools after steaming has been determined.

The process of warming glasshouse soils by means of buried resistance wires heated electrically has been further examined in relation to different air temperatures. It has been proved that the tomato crop varies distinctly in relation to both soil and air temperatures, maximum crops in these experiments being obtained at an average night temperature of 67·6° F. and a soil temperature of 68° F., the latter being the highest soil temperature that could be obtained by the heating cables employed. These results, in conjunction with those previously reported, suggest that the tomato crop could be increased if the average night temperature in commercial houses could be maintained at a higher degree than that usually employed, and that the crop will be further increased when an economic method for heating the soil is devised.

B. Cucumbers.

(*a*) *Sterilisation of old beds.*—The cucumber experiments were designed to determine the relative value of steam and formaldehyde as a means of sterilising cucumber beds and the soil on which they rest. Formaldehyde raised the yield 12 per cent. and steam 36 per cent. Obviously, therefore, the use of steam is to be recommended in preference to formaldehyde.

(*b*) *Composition of the bed.*—In another series of experiments normal beds of stable manure and loam were compared with those to which straw had been added, and as in previous years the addition of straw proved beneficial.

II. ENTOMOLOGY.

(*a*) *Red Spider.*—The Red Spider investigations have been continued, and a study of the life-history of the male mite has shown that there are the same number of moults as in the female, so that three stages are passed through before maturity is reached, instead of only two as originally described. The previous error was due to the comparatively short period of the protonymph stage, which occupies a few hours only, and its resemblance to the deutonymph stage.

The testing of substances as fumigants for the control of pests of glasshouse plants has been continued and, in addition, the relative toxicities towards the red spider mite (*Tetranychus telarius* L.) of the vapours of members of homologous series of compounds have been determined under standardised conditions.

The results obtained for the aliphatic monohydric alcohols, their formic esters and the methyl esters of a number of the fatty acids show that the toxicity of the normal compounds increases up to a maximum, and then decreases, on ascending the series, and that the toxicity of isomers decreases with increased branching of the chain. Methyl formate is, however, an exception to the above generalisation.

Experiments have been made to find a substitute for the petroleum-oil emulsion sprays used in the control of the red spider mite on account of the damage to tomato plants at certain periods of their growth resulting from the use of such emulsions.

A sulphonated petroleum derivative giving complete control of the mite at low concentrations is being tested regarding its action on tomato plants.

(*b*) *The White Fly Parasite.*—The number of applicants supplied with boxes of White-fly parasite has been 827, as compared with 578 in 1929. The number of boxes sent out has been 3 large, 160 medium and 696 small size, making a total of 859. The breeding and distribution of the parasite during the past four years has led to the reduction of the white-fly population in Hertfordshire glasshouses to an almost negligible quantity.

III. MYCOLOGY.

(*a*) *Tomato Leaf Mould.*—The effect of various sprays and fumigants on tomato leaf mould, *Cladosporium fulvum*, has been determined. On pot plants, control was effected by spraying with either liver of sulphur, Shirlan, ammonium copper carbonate, ammonium polysulphide, lime sulphur or colloidal sulphur when Agral 1 was employed as the spreading agent. They were much less effective with Saponin as a spreader, and the increased efficiency seems due to Agral 1. Quinone as a fumigant gave promising results, and is being tested further. In fumigations with Sulphur, the spores were destroyed on the upper surface of the leaf only

Experiments also indicate that glasshouses can be freed from infection by fumigation with formaldehyde, by the burning of sulphur, but not by spraying with cresylic acid.

The incidence of leaf mould and its relation to environmental conditions has been studied further. Conditions were more favourable to the disease in 1930 than in 1929, and it has been correspondingly more severe and, as in 1929, soft plants suffered most.

The optimum and maximum temperatures for spore germination are 72° F. and 77° F., respectively; the minimum temperature has not been found, but spores germinate at 38° F. The thermal death point is about 115° F. Spores on diseased leaves in glasshouses were not killed by exposure to high temperatures on several consecutive days, and germ tubes, which had been dried for several hours, recommenced growth when placed in water.

(*b*) *Mosaic disease.*—The investigations relating to Mosaic disease have been continued, and successful control of this disease in both cucumbers and tomatoes by the use of clean seed has been confirmed.

The investigation of physical and chemical characteristics by which the infected tissue may be distinguished from normal tissue and the study of the influence of environmental and other conditions on the severity type and development of symptoms *in vivo* has been extended. The physical properties studied include fractional absorption, electrophoresis, absorption spectre in ultra violet light, fluorescence in ultra violet light, phosphorescence in visible spectrum and behaviour in dialysis. The action of the infected sap on chlorophyll *in vitro* and some of its enzymic properties have been examined.

The progress and severity of the disease in the living plant has been studied in relation to light of different wave lengths, duration and intensity of light, metabolism and inoculation methods.

While further work is necessary before definite conclusions can be published, the results already obtained indicate definite progress along certain lines both in the evolution of methods of attack and data obtained by these methods.

IV. CHEMISTRY.

A comprehensive examination has been made of the soils from plots on which the same manuring has been repeated for a number of years. From the data it appears that the following conclusions are justified.

The omission of phosphates or potash caused a reduction in the total nitrogen.

The omission of nitrogen or potash caused a reduction in the total phosphoric acid (*i.e.*, soluble in hydrochloric acid).

The omission of nitrogen or potash increased the proportion of the phosphoric acid soluble in 1 per cent. citric acid solution.

In the unmanured plot the reductions in total phosphoric acid and potash were much greater than the reduction in total nitrogen.

The addition of 14 tons per acre of stable manure caused large increases in the total phosphoric acid and potash contents.

The plot receiving no potash showed a comparatively low value for calcium carbonate. Taken in conjunction with the low value for total phosphoric acid this may indicate that the intake of calcium by the plants is increased in the same way as the phosphate intake is increased in the absence of added potash.

In the plots which received graded amounts of potash no great differences were observed in total potash or potash determined by fusion, but real differences in the exchangeable potash were found.

D.

ENTOMOLOGY
and
PLANT PATHOLOGY.

17. PLANT PATHOLOGICAL LABORATORY, MINISTRY OF AGRICULTURE AND FISHERIES.

The functions of this laboratory are described on page 50 of the Imperial Agricultural Research Conference volume entitled "Facilities for Advanced Study and Research in Agricultural Science and the Cognate Pure Sciences in the United Kingdom," and it is sufficient here to point out that the Laboratory is not primarily a research institution. Investigations are carried out only in so far as other duties permit: such investigations are usually of a co-operative nature, planned and carried out jointly with members of the Advisory and Research Services, and reference to the same experiment may, therefore, occur in the accounts of work at several different stations. For a similar reason no account is given in this section of certain projects in which the Plant Pathological Laboratory is interested since they will be fully dealt with by the other Stations concerned.

Pyrethrum Investigations.—Small scale experiments previously referred to have shown that pyrethrum (*Chrysanthemum cinerariaefolium*) can be successfully grown and harvested under English conditions and that the dried flowers possess insecticidal properties at least as powerful as those of samples grown elsewhere. A number of larger plots (half an acre or more) have been planted from seed produced at the Pathological Laboratory with the object of obtaining data as to the costs of cultivation and harvesting, and four of these plots have given their first crop this year. In each case the plants have grown well and the flowers have been successfully harvested, dried and sold. It would be very unwise to draw any conclusions as to the economic possibilities of the crop from the results of one year's work, but it can be said that the figures so far obtained fully justify the continuation of the experiments.

Small supplies of seed for the establishment of experimental plots have been forwarded to various parts of the Empire, and it is hoped that reports as to the progress made will be received in due course.

Plots of pyrethrum of several different strains are maintained at the Ministry's laboratory in order to have a supply of flowers for experimental purposes and for seed production. The laboratory study of the yield and percentage of the insecticidal principles (Pyrethrins I and II.) in individual plants, and in flowers at different stages of maturity, etc., is being continued in collaboration with the Insecticide Department at the Rothamsted Experimental Station. Some plants with an exceptionally high percentage of pyrethrins in the flowers have been found.

Potato Eelworm Investigations.—The work referred to in the previous report has been continued and extended. Evidence was obtained which showed that the eelworm was partly but not entirely responsible for "Potato Sickness." Tubers grown in "sick" soil from which the eelworm cysts had been removed by sieving showed

a great increase of crop over those grown in untreated soil, but only half that of tubers grown in similar soil which had been partially sterilised by steam. In 1929, tubers grown in soil which had been sterilised and infected with cysts developed normally, but in 1930, plants grown in the same soil without further treatment failed entirely. This seems to shew that a second factor, connected with the condition of the soil, is involved in the trouble : where this is present the plants will succumb to the attacks of the eelworm, while on the other hand, a vigorously growing plant will be unaffected.

Woolly Aphis Parasite.—The colony of *Aphelinus mali* at Chislehurst, Kent, which was referred to in the previous report, has persisted throughout the winter and has spread considerably. At Barnstaple, Devon, where the parasite was liberated in 1926, it has persisted, but only in small numbers until the present year, when a considerable increase in the size of the colony has taken place.

Root Fly Experiments.—Co-operative experiments carried out by the Laboratory in conjunction with members of the Advisory Service have shown the value of naphthalene as a deterrent for the Cabbage Root Fly, the Onion Fly and the Carrot Fly under English conditions.

Bulb Diseases.—Special attention continues to be paid to the diseases of the commoner bulb and corm-forming flowering plants, and to the incidence and distribution of these diseases in this country. In the period under review two fungi new to the British flora were encountered. *Leptosphaeria heterospora* was found on the roots and rhizomes of *Iris germanica* and a fungus, provisionally identified as *Kabatiella microsticta*, was observed causing leaf spotting of *Lilium umbellatum* and *L. Wilmottiae*. In addition, *Stagonospora Curtisii*, hitherto known only on Narcissus, proved to be the cause of a rot destroying bulbs of *Galanthus byzantinus*.

Potato Blight.—To test the hypothesis that the incidence of Blight in potatoes varies with the age of the plant at time of infection, the experiments begun last year in collaboration with the provincial Advisers was continued. Blight did not appear in the garden at the Pathological Laboratory until very late in the season, so that again no result of value was obtained there. At some of the provincial stations, however, the results seem to suggest that while younger plants are not by any means immune from attack, yet when infection has once occurred Blight appears to make more rapid progress in maturer plants. Factors other than loss of supposed inherent resistance due to age may account for this.

Potato Sickness.—In view of the failure in the preceding year to reproduce this trouble by the addition of *Corticium* (*Rhizoctonia*) *Solani* (with or without eelworm cysts) to sterilized soil, experiments were set up to discover if any other fungus was constantly associated with it. Soil in which severely affected plants had appeared during the previous season was procured, and potatoes were planted in

it in pots. As controls, plants were grown in sterilized portions of the same soil. In spite of careful search (especially of the roots) from the time growth began, no organism (except the eelworm) was found in constant association with the plants.

Experiments were also devised to discover if the trouble could be avoided by late planting. Tubers were planted in unsterilized "sick" soil at fortnightly intervals until the middle of July, but the later planted individuals showed little or no improvement on those planted earlier.

Lettuce Rust.—Some time was devoted to the study of a very rare Rust found in a very small amount on lettuce plants imported from Holland in May, 1930. There is little doubt that the Rust involved was *Puccinia Opizii*, a fungus that has not previously been seen in this country. Indeed, it has apparently only twice been observed occurring naturally on the cultivated lettuce, a long interval separating the two observations. It was found in Germany in 1892 and was not seen again until it appeared in Poland in 1928. At present this Rust is of mycological rather than pathological interest.

The work in Canker and Dry Rot in Swedes in progress at the Reading Advisory centre in conjunction with the Ministry's Plant Pathological Laboratory has been continued, the previous season's conclusions having been confirmed and extended.

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18. POTATO VIRUS RESEARCH STATION, CAMBRIDGE UNIVERSITY.

The work of the Institute, apart from that of the entomologist, has been in three directions :

(1) The isolation and multiplication of virus-free stock of potatoes.

(2) The testing in a large number of situations in Great Britain of such stocks.

(3) Research into the nature of the virus diseases affecting the potato.

1. To the varieties already isolated, Abundance, Arran Chief, Arran Comrade, Arran Victory, Epicure, Great Scot, King Edward and President, have been added stocks of Arran Crest, Champion, Di Vernon, Eclipse, Kerr's Pink, and Majestic. Of these latter groups, whilst it is not yet possible to assert that they are indeed virus free, it may be said that neither in the glasshouse nor in the first year outside have they shown evidence of disease ; nor has grafting to test plants, etc., shown them to be other than normal. We have a stock of Up-to-date which has been under test for three years and which cropped outside this year in a manner which recalled the days of 25 years ago when Up-to-date not only produced bumper crops but colossal tubers.

2. Stocks of Great Scot, Arran Victory, Epicure and some others which had been grown in the open for at least two years either at Barley or Thetford were sent to 33 stations in localities as differently situated as Newton Abbot in the south and the Orkneys in the north, Boston in the east and Aberystwyth in the west. Several of the reports show that these stocks have not remained free of virus, but had evidently acquired a certain amount in the previous season of both mosaic and leaf roll. On the other hand, they almost invariably refer to the outstanding vigour of the haulms and the large crops produced.

There have, in addition, been conducted seven statistical yield trials on three or more of the Institute's stocks: the considered report on these is not yet ready but it may be said that although virus disease is noted in most, the yields have generally equalled or beaten that of the stock seed from Scotland with which they have been compared.

3. Research this year has been much hampered by the fact that the assistant's post vacated by Mr. Cory in October last was not filled till August 1st, when Mr. Bawden was appointed. The Director, with the assistance of Miss O'Connor, has, however, carried on the research on Crinkle and paracrinkle and more particularly has checked the results previously obtained.

An interesting observation, which may be of value, has been made on King Edward. The Institute's stock of the variety which, like all others so far examined, carries in a latent form 100 per cent. paracrinkle but is free of all other virus diseases, has been induced to display the symptoms of its latent paracrinkle by being kept in store till July and allowed to grow long sprouts. As its latency has hitherto proved to be very complete, it is hoped that alterations in dormancy may have like effect on other carriers.

Certain work has been done on the anaerobic inoculation of virus but no results of value have so far accrued.

The work on the Inheritance of Phytophthora, which Miss O'Connor has been looking after, is progressing and several more highly resistant seedlings have been isolated.

A statistical trial of yields from the eyes of the rose middle and heel ends of tubers of the variety King Edward has been carried out and will be reported on later.

The work on colour and other mutations has been continued

Report of the Entomologist.—Research has been carried out upon the following subjects:

(i) Plant carriers of virus and the dissemination of their latent viruses by the aphis *Myzus persicae* Sulz.

(ii) On some further insect vectors of the virus of potato leaf roll.

(iii) On an undescribed plant virus capable of attacking the Solanaceae.

(i) (*a*) In the course of studies upon latent viruses, it has been found possible to produce different symptom expressions in tobacco plants by needle and aphis transmission respectively of the sap from the same potato plant, a symptomless carrier, Di Vernon.

(*b*) Potato Up-to-date carrying a latent streak virus, when grafted on the black nightshade, *Solanum nigrum*, produced a faint dark green mottle. When such a *S. nigrum* plant was grafted to the woody nightshade, *Solanum dulcamara*, no symptoms whatever were produced. The virus could, however, be recovered from such a *S. dulcamara* by grafting, but not by aphis. *S. dulcamara* is thus shown to be a perfect carrier of certain potato viruses.

(ii) Two further species of aphides capable of transmitting the virus of potato leaf roll have been discovered. These are the potato aphis *Myzus pseudosolani* and the glasshouse aphis *Myzus circumflexus*.

(iii) A new plant virus has been discovered originating in the dandelion (Taraxacum). This virus is transmissible under certain conditions to the Solanaceae, including such plants as the potato, tomato, tobacco, Datura and *Solanum nigrum*.

A survey is being made by Mr. J. P. Doncaster of the insect fauna of the potato plant on varying types of soil and in different environments. Later it is hoped to extend this survey to Scotland, and an attempt will be made to correlate incidence of potato virus with distribution of the aphis vector *Myzus persicae*.

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19. SILVER-LEAF DISEASE INVESTIGATIONS, CAMBRIDGE UNIVERSITY.

Further experiments on the injection of healthy plum trees with non-living extracts of *Stereum purpureum* have been carried out. In addition to the extracts which have hitherto been used in this series of experiments, a purer type has now been prepared by means of precipitation with alcohol. This method of preparation has the additional advantage that living mycelium or spores of *Stereum purpureum* cannot possibly be introduced into the trees. The results obtained with the alcohol-precipitated extracts confirm those given by the water-extracted fluids. The only differences are that the silvering symptoms sometimes appear more quickly with the alcohol-precipitated extracts, while the toxic symptoms (tip-browning, etc.) on the leaves are not nearly so marked as with the water-extracted fluids.

Some years ago a number of Common Plum and Myrobolan stocks were worked with the variety "Victoria" in two different ways. Some of the stocks were budded and grafted low down, as is the usual nursery practice, while in others the point of working

was about 4 feet above the soil. The trees were then planted out at East Malling and were kept under observation for a period of years with a view to comparing the natural incidence of Silver-leaf disease on those worked high and low respectively. These trees have remained, however, almost entirely free from the disease. It was decided, therefore, in 1930 to test these trees by means of a spore-inoculation experiment of the usual type. This was done in March, and all the inoculated wounds became silvered during the summer. It remains to be seen whether the differently worked trees will show differences in the amount of recovery from the disease.

The investigations which have been carried out during the last three years on the incidence of Silver-leaf disease in young nursery trees and in plum stocks indicate that in nurseries the danger of serious infection by *Stereum purpureum* is far greater in connection with the wounds made in cutting back after budding than the danger which may arise from using silvered suckers as stocks, although the use of the latter should not be countenanced. No evidence has been obtained during these investigations that *Stereum purpureum* may remain dormant in young trees kept under good nursery conditions and that it may become active when the trees are established in commercial plantations.

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20. BIOLOGICAL FIELD STATION, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

The work of inspection of consignments of cacao, dried fruit and other commodities at the London Docks has been continued, and by arrangement with the Liverpool Cacao Association, samples of West African cacao arriving at Liverpool have been sent to Slough for examination. Special attention has been given to the infestation of dried fruit and a survey has been made of the conditions prevailing in Copra with special reference to the presence of moulds.

The study of the climatic conditions prevailing in warehouses has been begun.

Biological work has consisted mainly in the rearing of stocks, and now stocks of 28 species of insects are being kept up. Of these, stocks of 11 species are numerous and strong.

Experimental biological work is concerned with the relation of humidity to the development of stored products insects and with the effects of very low and of very high temperatures.

Biological work in Mycology has been concerned with the determination of the moisture content of West African cacao beans, and its relationship to infestation of moulds. A large number of moulds have been found to occur on West African cacao on its arrival in the United Kingdom. Of these the *Aspergillus glaucus* group are the most commonly found. An investigation into a method for the

determination of the comparative fat-splitting activities of certain copra moulds has been conducted by Mr. J. C. Eyre, and indicated that a strain of *Aspergillus flavus* was the most active of the moulds used.

Mr. T. R. Vernon, recently appointed by the Government of New Zealand to investigate moulds detrimental to cheese imported from New Zealand into this country, has been given accommodation at the Field Station.

Chemical work carried out has been hampered by an inadequate electric power supply, which has prevented experimental work on a large scale. Meanwhile useful work has been done in the laboratory on the investigation of the vapour pressures, rates of diffusion and relative toxicity to insects of Carbon disulphide, Methyl formate, Methyl monochloracetate, Epichlorhydrin, Ethylene dichloride, Trichlorethylene, Carbon tetrachloride.

Revision of the Species of Moths of the Genus Ephestia.—The need for a knowledge of the distribution of the moth *Ephestia elutella* which arose in the tobacco investigation has led us to revise the species of the genus *Ephestia*, and Mr. O. W. Richards has now completed a revision of the genus which deals with the taxonomy of the species, their geographical distribution and their biology, so far as it is known.

In this work we are specially indebted to the Natural History Department of the British Museum, the National Science Museum, Washington, the United States Bureau of Entomology, and to various private collectors for the loan of material for study.

Investigation of Fertility in Plodia and Ephestia.—Miss M. J. Norris was appointed for this work and began duty in October last. She has made a careful study of the reproductive organs in *Ephestia* and *Plodia*, and a paper embodying the results of this work is ready for publication. The main features of it are that the male and female organs have been described, together with the formation during pairing of the spermatophore.

A review has been made of literature relating to the problem of infertility in insect eggs, and experimental work has been begun. The following is a summary of the results so far obtained. They refer in the main to *Ephestia kuhniella*, which has been used because of the scarcity of the stocks of *Plodia* at a time when the work was begun.

Feeding experiments showed that when whole meal, pollard and white flour were used, the following results were obtained :—

1. The number of eggs laid was lower when white flour and pollard formed the food than when whole meal did.

2. The life cycle was almost always as long in duration on white flour as on whole meal.

3. On pollard the development was 25 per cent. slower than on whole meal; the life cycle occupied 7½ weeks as against 6 weeks.

4. On pollard the number of eggs was very slightly lower than those obtained from cultures reared on white flour.

5. On white flour infertility was 10 per cent. higher than on pollard and on whole meal.

6. On white flour the adult life was shorter, being 9 days instead of 12 in the males and 6 days instead of 8 in the females.

Experiments on density of population in relation to fertility are in progress, and the results, although still incomplete, show that overcrowding results in the reduction of the number of eggs laid.

Various possible causes of infertility have been considered, and some information is available on the following :—

1. Failure of moths to pair was unusual.

2. Pairing which did not result in the formation of spermatophore occurred very seldom.

3. No case has occurred in which spermatophore was devoid of sperms containing only accessory gland secretion.

4. Failure of the sperm to reach the sperm sac from the bursa is evidently a frequent cause of infertility, but its occurrence is naturally difficult to prove.

Certain experiments designed to show the effects of Carbon dioxide on fertility were planned, but have been deferred pending the renewal of the electric light supply.

Tobacco Infestation.—Certain investigations relating to infestation of tobacco in store are also being carried out at the Station.

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21. PLANT PATHOLOGICAL LABORATORY, DEPARTMENT OF AGRICULTURE FOR SCOTLAND.

The work of the Laboratory in its various branches—Research, Advisory work, Publications, Museum work, and preparation for Shows—has continued and increased during the year.

A new development may be noted, the institution of two projects for work outside the Laboratory.

1. *Bracken.*—Experiments on the biological control of bracken are being carried out on a brae above Garelochhead. This place was chosen because of a bracken disease of great mycological interest that has occurred and is continuing in the West of Scotland. The disease was particularly severe on this hillside.

A field worker, a hut, and small equipment have been installed. At present the mycological work is being carried on by the Departmental staff and Professor Braid, of the West of Scotland College, but arrangements are being made for the appointment of a full-time worker.

2. *Strawberry*.—During the last ten years a disease of great virulence has attacked the strawberries in the Clyde Valley. This has been shown to be a Phytophthora of a type similar to the tropical root Phytophthoras. A small experiment station has been instituted and a field worker is installed to work out some form of control.

Routine Work.—About 500 cases of diseases of fruit, flower and vegetables were submitted for identification and advice as to control. Seventy diseases have been noted on seeds of economic crops, and work on this line has been tentatively initiated.

The collection of diseased specimens dry and in spirit now embraces two of each, and twenty special Museum preparations have been made and are regularly on loan.

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22. SEED TESTING AND PLANT DISEASES DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

Seeds.

Shipment of Grass-seed.—Laboratory evidence has been accumulated in an effort to determine the three lethal minima for the time-moisture-temperature-relation in perennial ryegrass by means of germination tests upon samples imbibed to definite percentages in an atmosphere of controlled moisture and then stored in sealed vessels for various periods at selected temperatures. The figures so far accumulated indicate—(1) That perennial ryegrass, after drying for periods up to 72 hours at temperatures up to 80°C. and tested immediately did not lose germination ; a drop appeared between 80° and 90°C. even after drying 24 hours ; at 100°C. 24 hours' drying caused a serious drop ; 72 hours resulted in complete loss of germination. (2) When stored at 13° to 14°C. germination was retained unimpaired for periods up to 63 days by seed whose moisture content ranged from 12 to 28 per cent. ; by seed stored at 25°C. for periods up to 39 days moisture content ranged from 18·5 to 29·3 per cent. when stored at 30°C., while seed having a moisture content of 17·6 per cent. retained its germination. A loss appeared in seed of 24 per cent. moisture after 17 days' storage and in seed of about 30 per cent. moisture a very serious drop (30 per cent.) after 10 days' storage. (3) Seed containing 24 per cent. of moisture, stored at 30°C., retained its germination for about 20 days, but lost heavily by the thirtieth day ; with a moisture of about 29 per cent., germination was lost seriously in the first fortnight and almost completely in four weeks. (4) Results of a period of drying following storage gave results suggesting recovery in a number of instances, but were inconclusive.

The results, as a whole, suggest that temperatures and moistures made within tropical crossings are sufficiently serious to injure germination, in view of the time during which the shipments may be exposed to them.

Ultra-Violet Light in Diagnosis of Lolium spp.—L. multiflorum (*Italicum*).—Seedling roots in contact with white Whatman filter paper have been found to cause patches in the paper to become luminescent when viewed under filtered ultra-violet light of the 3,000/4,000 A.U. Band. The chemistry of the phenomenon is not determined, but it is possible that traces of dextrine are produced. Seedling roots of *L. perenne* do not produce fluorescence. The paper appears to be a necessary factor since fluorescence is not produced on glass or porcelain, and the roots themselves in *L. Italicum* do not fluoresce externally although those of certain other species (e.g., oats) do so brilliantly. It has been found possible to distinguish seeds of perennial from deawned seeds of Italian by this method within a marginal error of 10 per cent. The test appears reliable for *L. Italicum*, but cases of apparent *L. perenne* are met with exhibiting fluorescence. The factors responsible for these anomalous cases are being investigated, and are probably referable largely to hybridization and segregation.

Purity of Ryegrass Strains.—Growing-on tests from commercial seed and controlled hybridization experiments suggest that ordinary strains are far from genetical purity, and the ordinary morphological criteria for distinguishing the two chief varieties frequently unreliable. Rolling and folding of leaves in the bud has been found very irregular, and theoretically impossible combinations of leaf and awn character are fairly common. There is ground for hoping that the fluorescence test mentioned above will help materially in solving the problem of diagnosis. Capacity for fluorescence appears to be retained in the mature roots where present in the seedling.

Weeds.

Sodium chlorate trials have been continued and have shown that in the treatment of creeping thistle spring application is less effective than autumn application. The salt has proved successful also in the destruction of nettles, bindweed, and of docks if a somewhat increased dose is used. Partial successes have been registered with ordinary doses against Bishopsweed and Burdock by spring application. It is probable that in the last three cases winter application would reduce the minimum necessary dose.

Seeds Mixtures.

Competition values of principal agricultural grasses and clovers in pairs under Northern Ireland conditions have been studied by means of crossed strip plots. The very strong combativeness of Italian ryegrass against all other species tried, including perennial, was an outstanding result in the hay analyses. Nevertheless perennial produced the greatest weight of hay sown alone. The analyses also showed an almost entire absence of wild white in the hay year, whether sown alone or crossed with other single species.

As a combatant against weeds only, the order of merit of the species tried was perennial, Italian (about equal), Cocksfoot, Red Clover (about equal), Rough-stalked Meadow Grass, Wild White Clover. Both ryegrasses competed strongly with Cocksfoot; the clovers did not.

All grass species tried competed strongly with Rough-stalked Meadow Grass, but Red Clover only weakly. It should be noted that the early summer was not conducive to good clover development.

Red Clover Strain Trials.

A further series of trials of late flowering red clover strains from various countries of origin have been laid down in collaboration with the Ministry of Agriculture and Fisheries.

The plots laid down in previous years examined in 1930 show good results from Welsh and English types, but poor from a number of foreign strains.

Potato Diseases.

Ordinary or Late Blight (*Phytophthora infestans de Bary*).—Owing to the increased attempt on the part of manufacturers to push the sale of dusting powders for controlling this disease, a more comprehensive series of trials in which six different dusts were used was carried out during 1930, their value being tested against that of Burgundy mixture. Blight was very severe during the season, and was first recorded in the plots on the 29th July, from which date it spread very rapidly. Conditions were such that all the spray materials under observation were accorded a thorough test. In no case did the results given by the use of any of the dusting powders compare favourably with those obtained by the use of Burgundy mixture. It is probable that the increased effort made to sell dusting powders in Northern Ireland during 1930 was due to the non-severity of the disease in 1928 and 1929—particularly in 1929, when dusting gave almost as good results as spraying. An account of these experiments is being prepared for publication.

A further series of experiments was conducted in order to determine the varying degrees of susceptibility to blight of haulms and tubers of potato varieties more lately introduced, and an attempt is being made to determine the methods by which tubers may become blighted in the field, with the object of devising methods of prevention.

Further experiments dealing with methods and materials used in the preparation of Burgundy mixture have been carried out, and the results of 1929 confirmed.

Pink Rot (*Phytophthora erythroseptica—Pethy. and Murphy*).—Further attention has been given to the study of this disease in the laboratory and in the field. The first part of the study of the physiology of the fungus has been completed and a paper is being prepared for publication. A second survey carried out during 1930 has again

shown the parasite to be widespread, but not causing serious damage to crops unless environmental conditions favour attack. Field experiments have been carried out on a farm where severe infection has frequently occurred, in order to investigate varietal susceptibility.

Flax Diseases.

Seedling Blight (*Colletotrichum linicolum—Pethy. and Lafferty*) *and Browning* (*Polyspora lini, Lafferty*).—A series of field experiments has been commenced in order to determine the value of seed treatment in combating these diseases.

Oat Diseases.

Oat Smuts (*Ustilago avenae* (*Pers*) *Jens. and Ustilago Kolleri Wille*).—The field work carried out in 1929 in connection with the treatment of oat seed for the prevention of smut and other seed borne diseases has been repeated. Formalin and Ceresan have again given complete control of smuts whenever they were used. In 1929 crops raised from seed treated with organic mercury compounds (Ceresan, etc.) were markedly better during the whole of the growing season, and yielded better than those raised from untreated seed. In 1930 this improvement was not so marked in the small scale plots during the growing season, but in an experiment carried out on a farm scale, the plots being one acre each in extent, an improvement was noted during the whole season and a very considerable increase in yield was obtained. From results which have already been obtained, it is clear that this problem is of considerable importance in oat cultivation in Northern Ireland, and it is proposed to extend the investigations already in hand.

Fruit Diseases.

American Gooseberry Mildew (*Sphaerotheca mors-uvae* (*Schw.*) *Berk*).—An account dealing with further investigations in connection with the control of this disease is in the press, and for the time being work on this problem has been stopped.

Apple Scab (*Venturia inaequalis Aderh.*).—The progress made during 1930 in connection with the campaign dealing with the summer spraying of apple trees for the control of apple scab has been far better than anticipated. In County Armagh, the centre of apple growing, it is estimated that at least 130 hand-operated cart spraying machines were sold for orchard use, while at least 7 power sprayers were in operation. Although extensive trials have been carried out in order to determine the relative value of different fungicides, no substitute has been found for excess-lime Bordeaux mixture.

Owing to the varying nature of the percentage of scab control obtained by summer spraying in orchards situated in different parts of the country, it was decided to investigate the effect of manuring on the incidence of the disease. In this connection a suitable orchard was taken in County Antrim, and a comprehensive manurial experi-

ment laid out. Interesting results regarding incidence of scab, and colour and hardness of fruit, have been obtained which would seem to have an important bearing on orchard practice. In 1931 it is hoped to repeat these experiments and to enlarge upon this aspect of the work.

Spring Frosts.—No late spring frosts causing damage to apple blossom occurred during 1930.

Winter Spraying.—During the year a tested tar distillate wash—Lethol—has been marketed by a local firm. This wash is manufactured according to the findings at Long Ashton. Further co-operation with the Chemistry Department of the Queen's University resulted in the preparation of a number of winter washes which were used in trials conducted to determine the value of such washes in securing the control of apple capsids. The results in this direction have not been encouraging, and in so far as Northern Ireland is concerned no winter wash has been found which has successfully controlled apple capsids. A similar series of experiments designed to determine the possibility of controlling the red spider (*Oligonychus ulmi*) by ovicidal winter washes did not yield promising results.

Forest Tree Diseases.

An account of the work carried out up to the close of 1927 in connection with the control of diseases and weeds in the forest nursery is in the press. Further experiments are in progress in connection with the use of aluminium sulphate for treatment of the seed beds as a substitute for sulphuric acid, which is now regularly used for the purpose of soil disinfection and weed control.

E.

AGRICULTURAL PARASITOLOGY.

23. INSTITUTE OF AGRICULTURAL PARASITOLOGY, LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE.

The Institute of Agricultural Parasitology consists essentially of a group of research workers engaged upon the study of the morphology, bionomics and life cycles, and of methods of control, of helminth parasites of animals and plants of economic importance.

Dr. T. Goodey has conducted further trials on several varieties of potatoes to ascertain their susceptibility to *Tylenchus dipsaci*. He has also studied this infection on oats in which the parasite produces "tulip root." The latter studies led to the accidental discovery of a new nematode parasite of the Frit-fly attacking oats. Detailed studies have also been made of the morphological differences between three genera of plant parasitic nematodes, *Aphelenchus*, *Tylenchus*, and *Cylindrogaster*. A new species of the genus *Cylindrogaster* has been described, and a paper has been published which deals with the nature of the reserve food bodies in the intestinal wall of certain plant—parasitic and free-living—nematodes.

Dr. D. O. Morgan has continued his observations on the parasites of sheep and goats, and has written papers summarising the results of his survey of helminth parasites of goats in Britain. He has drawn attention to the presence of a species in Britain which has only previously been recorded from goats in Turkestan. Dr. Morgan has devised a simple technique of diagnosis of lung-worm infestations, and has made detailed studies of the infective larvae of several of the intestinal forms.

Dr. E. A. Lewis completed last winter his survey of the incidence of helminths in sheep slaughtered for food at Aberystwyth. In the preparation of this important statistical contribution, Professor Greenwood and his staff have given valuable advice. It was with great regret that we received the resignation of Dr. Lewis from his part-time work at Aberystwyth on his appointment to the Colonial Service in East Africa.

Miss M. J. Triffitt, whose time is devoted entirely to the investigation of the eelworm *Heterodera schachtii*, particularly in relation to its pathogenic effect on potatoes and mangolds, has carried out numerous interesting experiments on the activating effect of the root excretion of the host plants and the deterrent action of root excretion of mustard on this nematode. She has also made field observations on the significance of weeds in the spread of the parasite. Field experiments have been carried out at the Ormskirk Potato Testing Station as well as at Winches Farm. Large quantities of infected soil have been brought by rail from Yorkshire to further these researches. We are indebted to the co-operation of Professor Raistrick in the determination of the chemical composition of the activating root excretion.

Dr. J. N. Oldham, whose special province it is to investigate the primary and secondary helminth parasites of insects, has found a comparatively high degree of helminth parasitism among the flea-beetles which are of considerable economic importance in agriculture. He has also found helminth parasites causing sterility in two species of elm-bark beetles which are of importance in forestry. Through the kind co-operation of Dr. Buxton he has been enabled to carry through the life-history of two helminth parasites in fleas derived from the squirrel. During the year his paper on a new cestode found in grey sand-hamsters, brought by Dr. Hindle from China, has been published.

During the summer, Professor Leiper attempted, in collaboration with Dr. Morgan, to ascertain experimentally whether the gapeworm so prevalent in starlings in this country is a potential source of danger to pheasants. Unfortunately, the hatch from artificially incubated pheasant eggs was exceedingly poor, and the number of pheasant chicks available for these studies was correspondingly small. One chick which received a large dose of gapeworm eggs died of acute infection of the lungs with immature gapeworms. It is hoped to repeat and extend this work next year under more favourable conditions. We have endeavoured to induce in pigs the severe damage to liver and lung produced by the migrations of *Ascaris lumbricoides* larvae by administering embryonated eggs of the ascaris of the horse. These experiments are still in progress.

During the past year the experimental plots at Winches Farm have been maintained and extended. A further portion of the Spedan Lewis Annexe, which is designed to provide uncontaminated plots for future experiments, has been put down to grass.

A new range of piggeries has been erected, and has been brought into use for the study of ascariasis in pigs.

The building of two cottages, designed by the chief architect of the Ministry of Agriculture, was begun in May, and these are now approaching completion.

The Imperial Bureau of Agricultural Parasitology, which occupies rented premises at Winches Farm, has worked in close and happy association with the research staff there, and has brought a considerable number of overseas visitors into touch with the workers there.

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24. DEPARTMENT OF HELMINTHOLOGY, DEPARTMENT OF ZOOLOGY, UNIVERSITY OF EDINBURGH.

Research.—(1) A number of fresh-water fish has been examined for helminth parasites at the request of the Fishery Board. The presence of larval stages of helminths in fish has attracted the attention of anglers in various parts of Scotland, and as yet, very little is known about the definitive hosts, and therefore of methods of prevention.

(2) The study of material collected in the British West Indies under the auspices of the London School of Hygiene and Tropical Medicine was continued, and several papers on this subject were published.

(3) The main line of research was a study of the bionomics of the Lesser Liver Fluke of sheep in Scotland. This parasite appears to be confined to the West. The available evidence suggests that a land snail is implicated as the intermediate host, and an intensive study of this species is in progress, and it is hoped to obtain a definite result during the coming year.

(4) In addition, a series of experiments has been initiated to attempt to find a means of cultivating parasitic stages of helminths *in vitro*. Up to the present, this difficult problem has not yielded satisfying results.

Miscellaneous.—A number of examinations of faeces for the presence of helminths was made, at the request of Veterinary Surgeons in Scotland : and a meeting of Scottish Veterinary Surgeons was addressed at Blairgowrie on the subject of the prevention of some of the more important parasites present in Scotland.

Liaisons with the abattoirs in Edinburgh and Glasgow were established in order to secure a supply of fresh parasitic material as and when required. Examination of this material has confirmed the opinion, which had already been noted ten years ago, that practically every sheep in Scotland is infected with parasitic worms. That the same is true for horses has been demonstrated by similar contacts with horse slaughter-houses. The losses due to helminths in pigs, dogs and cats, have also been found by enquiries during the year to be very considerable. The prevention of these losses opens up a field of enquiry which should be of the utmost consequence to stock farmers. A start is being made with the pig worm, which, at a conservative estimate, prevents one-fourth in number of all pigs born from reaching the market.

F.

ANIMAL PATHOLOGY.

25. RESEARCH INSTITUTE IN ANIMAL PATHOLOGY, ROYAL VETERINARY COLLEGE, LONDON.

1. *Mastitis in bovine animals.*—Research on various aspects of this problem has occupied most of the attention of three members of the professional staff during the year.

(*a*) *Bacteriology.*—(i) A report of a preliminary nature dealing with the bacteriology of 113 clinical cases of mastitis was published in December, 1929. Of these cases 82 were due to streptococci. Since that date many more strains have been collected, with the object of defining more clearly the characteristics of the haemolytic and non-haemolytic streptococci associated with mastitis, and in a more general way of streptococci encountered in udder milk. The work is progressing on biochemical and serological lines, and a number of streptococcus strains originating from disease in human beings are being included for comparison.

(ii) An investigation is proceeding in connection with the human skin-reacting substances produced by a certain type of non-haemolytic mastitis streptococcus. Experiments point to these substances being of nucleoprotein nature and not analagous to "exotoxins" of the scarlet fever type.

(*b*) *Clinical Forms.*—In addition to the ordinary chronic form of streptococcus mastitis attention has been drawn to a less common and more acute form which sometimes occurs in quite young cows or first-calf heifers. The local changes may lead to necrosis and speedy atrophy of the affected quarter. In the cases examined the causal organism was the non-haemolytic streptococcus referred to in (*a*) (ii).

(*c*) *Diagnosis of chronic streptococcus mastitis.*—Two papers on this subject have been published during 1930. The first of these was concerned with the brom-cresol-purple test, while the second was of more extended scope and dealt with :—

Cultural and microscopic methods of diagnosis ;
Diagnosis by observation of the amount and characters of the sediment obtained by centrifuging a fixed volume of milk ; and,
Diagnosis by the brom-cresol reaction.

Under the conditions of the work microscopic examination for streptococci was found to reveal just over 50 per cent. cases. As applied to milk samples from individual quarters and at a single examination, the sediment test may be expected to reveal about 70 per cent. cases of chronic streptococcus mastitis. In this work one volume of pathologically altered sediment per thousand volumes of milk was taken as representing the smallest quantity which should be regarded as abnormal. Under similar conditions, the brom-cresol test (applied by means of brom-cresol papers) was found to give a frankly positive result in 25 per cent. instances, was frankly negative in 35 per cent., while the reaction was "intermediate" in 40 per cent. instances. The value of the sediment and reaction

methods is increased if they can be applied to samples of quarter milk several times at intervals. Both methods are, however, in a sense supplementary, and at a single intervention neither attains in reliability a method involving cultural examination on a suitable medium of centifuged milk deposit. The labour attaching to the cultural procedure is diminished by the fact that it can be applied with considerable accuracy to a mixed sample of milk from the four quarters.

(*d*) *Control of mastitis.*—This work is now proceeding in six infected herds, of which four were originally badly infected. Briefly, the procedure is to pick out infected cows by suitable diagnostic methods and to have these milked last. An examination of milk samples from the uninfected group in each herd is carried out every three months. It can be said that so far the results are highly encouraging, though it would still be premature to issue any more definite statement.

2. *Johne's disease. Diagnosis and Control.*—Five infected herds have been tested with johnin at intervals, and the reactors are being gradually eliminated. So far as accommodation at the Institute and financial considerations permit, selected animals, mostly reactors, have been purchased for the purpose of making further observations connected with ante-mortem and post-mortem diagnosis.

Owing to the long drawn-out nature of investigations on this disease it is not yet possible to make any definite statements regarding the results. There is sufficient evidence, however, to say that in a number of cases the test has proved to be of considerable value for practical diagnosis.

3. *Bovine abortion.*—An immunological study has been made of a peculiar zone phenomenon encountered in certain agglutinating sera from cattle infected with Br. abortus. An account of this work is now in press.

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26. DEPARTMENT OF ANIMAL PATHOLOGY, CAMBRIDGE.

The following principal lines of enquiry have been pursued during the year.

Microbiology.

Filterable Viruses.—Mr. Glover has continued his investigations into the "in vitro" cultivation of the virus of *epithelioma contagiosum* by tissue culture methods, and has adduced definite evidence of the multiplication of the virus in media of the plasma clot type (Carrel method).

In attempting to induce an active immunity by means of artificially cultivated virus it has been found that the material is of a

lower antigenic value than that obtained from natural sources. The work is being extended with a view to developing simplification in technique, the ultimate object being to produce much larger quantities of the virus under artificial conditions and to overcome the difficulties met with in connexion with its practical application to immunological methods.

Contagious Pustular Dermatitis.—With a view to determining if more than one type of virus exists material has been obtained from a number of outbreaks of the disease in this and other countries, and the viruses have been tested by cross immunity experiments. So far, the results have shown that the several strains conform to a single type.

An examination of material from cases of " orf " a form of necrotic dermatitis of the feet of sheep in the Border Counties has shown that the virus is sometimes present in these lesions. Since the disease causes appreciable loss in condition in affected sheep it is proposed to test the practicability of preventive vaccination on a large scale along similar lines to those which have proved so successful in the case of pustular dermatitis. This virus has also been found in some outbreaks of mastitis in ewes, and the intra-mammary inoculation of experimental animals has shown that it is capable of setting up a low type of inflammation in that organ. It may, therefore, be primarily concerned in the causation of some outbreaks of ovine mastitis.

Bacteriology.

Mr. Bosworth has continued the enquiry into certain anaerobic infections in animals in the course of which a comparison has been made of the relative values as immunising agents of formolised vaccine and artificial agressin. The results show that the superiority of the former, as ordinarily prepared, is due largely to the antigenic properties of the dead organisms present and that the amount of aggressin contained in such a product is relatively small. In addition, he has investigated several outbreaks of paratyphoid infection in young calves.

Caseous Lymphadenitis.—This investigation, which was originally undertaken with a view to determining the susceptibility of British sheep to infection with the Preisz-Nocard bacillus and the distribution of the lesions resulting from several methods of infection, has been completed.

It would appear that the disease is readily conveyed to British sheep either experimentally or by natural methods.

Mr. N. S. Barron has examined several strains of Preisz-Nocard bacillus, isolated from the glands of sheep affected with caseous lymphadenitis, in respect of their cultural characters, staining reactions, toxigenic properties and pathogenicity in small laboratory animals.

B. welchii.—A comparative study of many strains of organisms of the *B. welchii* group has been made by Mr. A. J. Wilsdon and Mr. J. A. Nicholson. The former has examined a number of strains obtained from different sources especially in regard to their morphological, cultural and toxigenic characters, while Mr. Nicholson has been engaged more particularly in studying their biological properties. An attempt is being made to formulate a satisfactory classification of the several members of this group.

Staphylococcus Toxin.—Mr. R. A. Hammond has investigated the toxigenic properties of several strains of staphylococcus aureus isolated from cases of gangrenous mastitis in ewes, and is conducting an experimental study of immunological methods in this connexion.

Immunity.

Vaccination of calves against Tuberculosis with B.C.G. Vaccine.—During the past twelve months the joint investigation carried out on behalf of the Medical Research Council and this Institute by Dr. A. Stanley Griffith and Professor Buxton into the immunising properties of B.C.G. vaccine in young calves has been continued. The selected method of immunising to which reference has been made in earlier reports is being pursued on a larger scale, while the method of administering the test dose has been modified so as to resemble more closely a natural infection.

The past year has seen the completion of the buildings generously provided by the Empire Marketing Board for the accommodation of cattle in connexion with B.C.G. vaccine experiments. It will now be possible to continue this work on a more adequate scale, and it is hoped that the information already obtained will be augmented in the near future.

Physiology.

Mr. Bellerby has continued his investigation into methods for the preparation and separation of the follicle stimulating and lutealising principles of the anterior lobe of the pituitary. During the winter months all the changes in the ovaries, uteri, vulvas, etc., of normal oestrus were produced in the anoestrus female ferret by the injection of extracts of the anterior lobe of the pituitary and of human placenta. From observations which have been made, it would appear that anoestrus may be due to diminished activity of the anterior lobe during winter.

Further work in connexion with the factors involved in the production of pseudo pregnancy in the rat has shown that neither pregnancy nor pseudo pregnancy results from copulation when the uterus is anaesthetised. This has been found to be due to the fact that fertilised ova are not implanted as a result of the absence of receptive changes in the uterus caused by non-formation of functional corporea lutea in the ovaries.

The investigation of sterility in female rats which have been fed on diets rich in cod-liver oil has been completed. It has been ascertained that this may result from :—

(*a*) failure of the oestrus cycle,
(*b*) resorption of the developing embryos, or
(*c*) failure of the birth mechanism, the young developing normally to full term, but are not produced, the mother dying in coma.

Histology.

Hypervitaminosis D.—In collaboration with Dr. L. Harris, of the Dunn Nutrition Institute, Mr. J. R. M. Innes has pursued his investigation into the morbid anatomy of hypervitaminosis D with special reference to (*a*) the importance of the calcium and phosphate balance in the diet and its relation to the severity of the pathological changes induced by massive doses of irradiated ergosterol, (*b*) the effect of excessive doses of irradiated ergosterol on the calcification of bones and teeth in experimental animals, and (*c*) the effect of the balance of calcium and phosphate in the diet on the teeth and bones when given with normal on massive doses of irradiated ergosterol.

Experimental Scurvy.—The pathology of experimental scurvy in the guinea pig has been studied with special reference to the changes occurring in the bones and teeth during the latent period of the disease prior to the onset of clinical symptoms.

Comparison was made of the changes observed in bones and teeth of animals on diets partially or completely deficient of vitamin C. As a result of this study it is believed that practical use may be made of the changes in the teeth as a test for the vitamin C content of a diet.

In collaboration with Professor W. Mitchell, Royal (Dick) Veterinary College, Edinburgh, an examination is being made of the teeth and bones of horses suffering from conditions which are suspected to be complicated by the presence of scurvy, in order to determine if similar changes are present.

Investigation is being made of the histology of the lesions produced in experimental animals by toxic doses of B. welchii toxin.

Mr. A. C. Fraser has completed his study of the blood of cattle and sheep in health and when suffering from a number of diseases.

Numerical standards were obtained for adult animals and for young animals of various ages from within a few hours of birth to the adult state.

Comparison has been made of these standards and the numerical findings in the several pathological conditions. In addition, the histology of the blood elements in health and in disease has been recorded.

Biochemistry.

Investigation into the effects of nematode worms on the metabolism of sheep.—The work carried out by Dr. Stewart and Mr. Shearer, which was referred to in a previous report to the Ministry of Agri-

culture, has been continued. More recent observations have been made with animals suffering from light infestations, and the results have been in accord with those obtained in connexion with heavy infestations, namely, that while digestion and absorption of fat and carbohydrate do not appear to be affected, full use is not made of the protein constituents of the diet. These experiments are being repeated with sheep infested artificially with known species of parasites.

Cellulose Digestion in the Ruminant.—Comparison has been made of the amounts of fibre digested in the ruminant and by the cellulose-splitting organism (referred to in previous reports) in vitro. An attempt is being made to ascertain the significance of the chemical composition of the food and the biochemical action in the rumen in relation to the digestion of cellulose by the organisms.

Eclampsia of Ewes.—A biochemical survey has been made of the blood and urine of normal ewes during pregnancy and parturition. In the early part of the year these investigations were continued in Northumberland when a comprehensive examination was made of the chemical composition of the blood and urine during normal pregnancy and in many cases of disease commonly met with in those parts. Several naturally occurring cases of eclampsia have been studied from this point of view. Based upon these observations attempts have been made to produce the symptoms of eclampsia experimentally by inducing alterations in the mineral balance and by interfering with normal metabolism. So far, it has not been found possible to produce typical clinical symptoms even when the conditions in the blood which are supposed to be associated with or responsible for the symptoms have been reproduced experimentally.

Parasitology.

Colonel W. A. Wood has completed the study of several hitherto undescribed nematode worms obtained from the stomach and intestines of kangaroos (*Macropus Woodwardi*).

The number of routine examinations of material submitted for diagnosis and of specimens for identification has increased very considerably.

Much useful information has been obtained regarding the value of oil of chenopodium in the treatment of parasitic enteritis of horses and will be published at an early date.

Routine Diagnosis.

The value of the work carried out by this section is evidenced by the number of requests for assistance received from veterinarians and stockowners. Since the inception of the department there has been a steady increase in the specimens submitted for examination, and during the past year 4,518 have been dealt with. The value of this work to the Institute is of no less importance for it has brought to the notice of the staff many problems which might otherwise have escaped proper attention.

27. VETERINARY LABORATORY, MINISTRY OF AGRICULTURE AND FISHERIES.

A. Foot and Mouth Disease Experimental Station, Pirbright.

(*Under the general direction of the Foot and Mouth Disease Research Committee.*)

Further work has been done on the survival of the virus outside the animal body, and particular attention has been paid to the influence of the substratum on which infective blood or epithelial shreds may have dried. The new refrigerating plant has been utilised for a series of experiments on the survival of the virus in beef carcases, and it has been shown that bone marrow may still be infective (to swine) after 80 days at "chilling" temperature (29° F.). Observations have also been made on survival in such materials as hides and prepared sausages casings, and this work is being continued.

Further work on the action of disinfecting substances has been carried out, with the object of determining the most suitable agents for special purposes, such as the disinfection of hides.

Material has been received from all the field outbreaks in this country, and in each case the immunological type of the virus has been determined. This work has confirmed that of previous years in showing that the great majority of the outbreaks in Great Britain are due to viruses of the "O" type.

No "A" or "C" type strains have been encountered, but several outbreaks have been proved to be due to virus strains that could not be included in any of the three recognised groups. The other properties of the various strains have been investigated, and practically all strains have been adapted to the guinea pig.

An extensive study has been made of the disease in the rat, and rats have been infected, not only by artificial methods of inoculation, but also by feeding infective material and by contact.

A series of observations has been made on the duration of "humoral" and "histogenic" immunity to foot and mouth disease in cattle. Work is in progress on the distribution of the virus in the bovine body, and its appearance in, and disappearance from, the blood and urine.

B. Veterinary Laboratory, Weybridge.

Babesiosis and Anaplasmosis.—Strains previously obtained from South Africa and South America, and those recently received from Prof. Brumpt, were kept up. During the year, 55 pedigree cattle were immunised before their dispatch to Brazil.

Scrapie.—No new work was undertaken, and there were no further developments in the experimental flock.

Contagious Abortion.—During the year 22,828 doses of the living vaccine were prepared and issued, and nearly 700 agglutation tests were carried out for the purpose of confirming the diagnosis, prior to vaccination.

Experiments were carried out with pregnant goats, in the hope that these animals might usefully and most economically replace cattle in work on contagious abortion, but the results were highly unsatisfactory from that point of view, and three different strains of *Br. abortus* failed to induce abortion or to set up prolonged infection of the goats.

The following points are at present under investigation :—

(*a*) The significance of the agglutination of *Br. abortus* by bovine serum in low dilutions.

(*b*) The virulence of strains of *Br. abortus* after prolonged cultivation in the laboratory.

(*c*) The appearance of *Br. abortus* in the udder and milk as a sequel to the subcutaneous inoculation of living cultures (vaccination or " premunisation ").

Tuberculosis.—During the year, 1352 doses of B.C.G. vaccine were prepared and issued to veterinary surgeons for field trials in selected herds. A few autopsies were performed on vaccinated animals, and a considerable amount of information was collected, but on the whole the field evidence was conflicting and difficult to interpret.

The incidence of avian tuberculosis is being studied, and some of the properties of the avian type of *B. tuberculosis* are under investigation.

Swine Fever.—The investigation referred to in the 1928–1929 report on the viability of the filterable virus of swine fever in bone-marrow, skin, and muscle has been completed.

It was found that the virus survived seventy-three days (not end-point) in the bone-marrow of salted, and chilled, carcases.

It survived forty-two days in the skin and muscle of salted carcases.

The virus content of skin and muscle of pigs killed in the early stage of infection is relatively low, but as the disease progresses it becomes markedly concentrated. A report on this work will be published in the near future.

Ostertagiasis in Sheep.—A test on the longevity of the larvae in hay has been carried out.

A comparison has been made of the growth and development of worm-free lambs, and of lambs infected with Ostertagia.

Life History of Moniezia.—Field experiments have been continued.

Konsuloff's claim to have found the larval stage in ewes' milk has been tested by feeding experiments, but with negative results.

Ascariasis.—Experiments on the biological identity of *Ascaris lumbricoides* of human and porcine origin have been continued.

The experiments to determine the part played by Ascaris larvae in aiding bacterial invasion of the animal body have been completed. No evidence was found to support the suggestion that the larvae may play an important role in that respect.

Dermatitis due to Cercaria ocellata.—Biological experiments have demonstrated the ability of this cercaria to penetrate skin, and to set up a dermatitis.

Biological experiments have also been carried out with another cercaria which penetrates the skins of fishes and migrates to the lens of the eye.

Contagious Ophthalmia in Cattle.—With the aid of members of the Field Staff of the Ministry, observations have been made on a few outbreaks of a bovine conjunctivitis and ophthalmia that appeared to be contagious. Affected animals were brought to the laboratory, but all attempts to transmit infection to healthy cattle proved unsuccessful.

Fowl Pox.—Work on the elaboration of a vaccine against fowl pox has been continued, and has been very successful.

The method is based on the observation that pigeon-pox virus and fowl-pox virus are immunologically indistinguishable, and that pigeon-pox virus protects fowls against natural infection with fowl-pox, without causing generalisation of infection.

A report on the work has been published in the J. Comp. Path. & Thera., Vol. XLIII, 1930. The following are the conclusions from that report :—

(1) Pigeon-pox vaccine confers a solid immunity on fowls against natural infection with fowl pox.

(2) Immunity is fully established about the fourteenth day after inoculation.

(3) The vaccine confers considerable, but no complete, protection against severe artificial infection with fowl-pox virus. It prevents generalisation of infection, and the lesions usually clear up quickly ; this is in contrast with the generalisation of infection, accompanied by loss of condition and heavy mortality, which occurs in unvaccinated fowls.

(4) The vaccine does not give rise to any constitutional disturbance or loss of condition, nor, as far as has been ascertained, does it interfere with egg production.

(5) Susceptible fowls do not contract infection when kept in contact with fowls exhibiting active pigeon-pox lesions on the comb, mouth or skin.

(6) The virulence of pigeon-pox virus for fowls can be exalted by serial passage through fowls.

(7) In pigeon-pox virus we possess a valuable agent for the protection of fowls against natural infection with fowl pox. When employed in conjunction with hygenic measures, it should bring about a marked and rapid reduction in the incidence of the disease.

Since the publication of the report, the vaccine has been tested on more than three hundred thousand fowls on infected farms, under the varying conditions which obtain in the field, and the results have been uniformly satisfactory.

The vaccine gives a solid immunity of about four months' duration, but in view of the long time for which the pox virus can survive on infected premises, this is insufficient for absolute safety. Nevertheless, no secondary outbreaks among inoculated fowls on infected premises have been reported up to date.

It is hoped that when work on the vaccine can be resumed, it will be possible, by modifying the method of preparation, to increase considerably the duration of the immunity conferred by it.

Bacillary White Diarrhœa.—Further work on the possible transmission by contact of Pullorum disease (B.W.D. of chicks) from infected to healthy adult fowls has been carried out.

In previous experiments (J. Comp. Path. & Thera., Vol. 38, 1925) it was reported that attempts at transmission by contact had failed, but an opinion, based on the clinical history of outbreaks, was expressed that such transmission probably occurred.

In the experiments recently concluded, transmission of infection by contact between diseased and healthy adult fowls has been confirmed, but it usually occurs in only a small percentage of cases.

The outcome of contact experiments would appear to depend almost entirely on the distribution of *B. pullorum* in the system of the infected fowls. If in the carrier fowls the organism is confined to the ovary, as is frequently the case, contamination of the ground does not occur. But when foci of infection exist in the gall-bladder wall, liver or kidneys, the organisms pass out to the exterior, and healthy fowls pick up infection from the contaminated ground.

Avian Typhoid.—This disease continues to take heavy toll of the poultry flocks in certain areas. Over 5,000 doses of vaccine have been issued during the year, and many reports of its efficacy have been received from farmers.

Fowl Plague.—Attempts to prepare a reliable vaccine against this disease have been continued, but have proved unsuccessful, and the results obtained with Todd's method were not very encouraging. An atypical strain of virus from Egypt was compared with several standard strains; the disease induced by this virus differed quite definitely and consistently in several respects from that set up by ordinary strains, but immunologically the Egyptian virus was identical with the other strains kept at the laboratory.

The work on the survival at low temperatures of the fowl-plague virus in carcases has been concluded. At 34°—38°F. the virus

was found to survive as long as 287 days in muscle and 303 days in bone-marrow. It was also found to survive for 18 days in feathers exposed (in May and June) to out-door temperature but protected from rain and direct sun-light.

Contagious Catarrh (Roup) of Chicks.—The term "roup" is commonly applied to a number of different diseases of poultry with certain clinical characters in common, and particularly to fowl-pox. There is a form of contagious catarrh, with a mortality usually about 40 per cent., that is very common during some seasons, and is often associated with fowl pox. When fowl pox is excluded, this disease may be taken to be the commonest and severest form of "roup." Owing to the courtesy of Major G. W. Dunkin, of the staff of the Institute of Medical Research at Mill Hill, an opportunity has been afforded of closely investigating an outbreak of the disease.

The disease was shown to be due to a filterable virus, and the virus has since been recovered from other outbreaks in this country. A study of the virus and of the disease will be published shortly.

Tumours in Fowls.—Some work has been performed on the transmission by inoculation of certain tumours encountered in the course of routine post-mortem examinations.

Diagnosis.—In connection with the larger domestic animals, 5,507 specimens have been examined for evidence of infection with one of the "scheduled" diseases.

In addition to these, nearly 600 specimens were submitted for examination from animals not suspected to be suffering from scheduled disease.

In the poultry diagnosis department, 3,681 specimens have been examined, and more than 50,000 agglutination tests for bacillary white diarrhœa have been performed.

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28. ANIMAL DISEASES RESEARCH ASSOCIATION OF SCOTLAND.

Grass Disease.—During the season 1930 a very complete incidence survey of the disease was carried out, and attempts were made to correlate the affected areas with the geographical distribution of soil and forage insects. This led to suspicion being cast upon *Smynthurus viridis* as a factor possibly concerned in the production of the disease. Feeding experiments with this insect proved indefinite, and the work will be repeated in season 1931.

Louping Ill.—The transmission experiments carried out during 1929 were repeated, and it was found that the disease could be readily transmitted to healthy sheep by the intracerebral injection of material obtained from the central nervous system of cases of

Louping-Ill. The infective agent was found to be a filterable virus. It was further shown that the pig, the mouse and the rat could be infected by the virus.

It was found that sheep which received a subcutaneous injection of living virus were protected against subsequent intracerebral injection of the virus, and that a prolonged active immunity could thus be established.

The character of the virus is being studied with a view to the production of a protective vaccine.

It has been found that the pathology of the disease represents an encephalo-myelitis.

Milk Fever.—It has been shown that hypocalcaemia represents the essential pathology of Milk Fever in cows.

A curative treatment of specific efficacy has been found in calcium gluconate, and this treatment has proved so successful that it is being applied by practitioners throughout the country and abroad.

The problem of preventing the disease is now being actively prosecuted by the Biochemical Department.

Braxy.—A study of the organisms isolated from naturally occurring cases of Braxy is being carried out, and further studies on improved methods of immunization are in progress.

Certain features of the disease suggest that a relationship exists between its pathogenesis and thyroid dysfunction, and this aspect of the problem is now under investigation by the Biochemist.

" Pine " in Sheep.—In collaboration with the Rowett Research Institute, the condition known as " Pine," which occurs in the island of Tiree, is being investigated.

A chemical analysis of the pasture on the " thriftless " and the sound land has been made at regular intervals over a period of six months. The results suggest that the disease represents an acute mineral deficiency, and it is hoped to carry out crucial feeding experiments in the spring of 1931.

Scrapie.—The continued incidence of Scrapie is causing serious economic loss to Border flockmasters. All previous attempts to elucidate the nature of the disease by pathological and bacteriological methods have proved negative, and the problem is now being approached from a biochemical aspect.

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29. ANIMAL DISEASES DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

The chief subject of study during the year was bacillary white diarrhœa. The various methods of agglutination testing were investigated and a standard test fixed by the division. The high value of this test was indicated by the excellent field results which were obtained with over 48,000 birds.

An analysis of the testing records of 112 farms clearly indicated that the disease spreads naturally amongst adult birds. This conclusion was confirmed by experiments lasting twenty months. The method of spread was also ascertained.

Improved methods of diagnosing bacillary white diarrhœa in chicks gave valuable results. The disease was confirmed in turkeys.

The investigations on the etiology of bovine abortion were continued. Agglutination tests suggested that other organisms may be a cause.

Improvements were effected in the intra-uterine injection operation for sterility with reference to dosage and treatment of the *os uteri*.

Replies to a questionnaire sent to all veterinary surgeons in Northern Ireland showed that opinion was equally divided for and against abortion vaccines.

A preliminary experiment on lambing sickness in ewes did not yield evidence supporting the calcium deficiency theory.

G.

ANIMAL NUTRITION
and
ANIMAL BREEDING.

30. ANIMAL NUTRITION RESEARCH INSTITUTE, CAMBRIDGE.

Mr. F. W. Foreman has continued his investigations of the chemical changes occurring during growth in pure cultures of grasses and clovers, especially perennial rye grass. This work during the past season has included studies of the changes during the later stages of growth, namely, when the panicles, flowers, and seeds are developing, and the effect upon chemical changes of manuring with ammonium sulphate applied as successive top dressings at intervals during the season. A large amount of data already accumulated is under study. The fluctuations in the content of these index constituents embraced by the methods employed show a close relationship with changes in the environmental conditions. In some cases the fluctuations are large, indicating remarkable differences in the nutritive value of perennial rye grass from time to time. Some of the constituents present in considerable amounts at certain times have been isolated and work designed for the purpose of establishing their precise identity is in progress. The results illustrate the importance of employing pure cultures in attempting to elucidate the principles underlying growth and quality.

Mr. Foreman has also made progress in his work on the proteins of grasses and clovers and on the further improvement of methods of protein investigation. A method of insuring that fluids in which the behaviour of enzymes is being studied shall be quite aseptic during incubation, has been evolved, thus avoiding the confusion sometimes introduced by bacterial products in existing methods.

Dr. H. E. Woodman, in conjunction with Mr. D. B. Norman and Mr. M. H. French, has continued his investigations into the influence of the intensity of grazing on the yield, composition and nutritive value of pasture herbage. During the past two seasons, the effect of widening to a month the interval between successive cuttings (or grazings) of pastures has been investigated, and the results of the two years' work are in course of preparation for the press.

The work begun in 1929 on the influence of intensive fertilizing on the mineral and organic composition, the yield and botanical character of cultivated pasture has been continued during the season of 1930 by Dr. H. E. Woodman, with the collaboration of Mr. E. J. Underwood and Mr. M. H. French. Important results have been obtained and an account of the two years' work is being prepared for the press. The work is being continued.

Dr. H. E. Woodman, in conjunction with Dr. R. E. Evans, recently completed an investigation into the utilization by sheep of mineral-deficient herbage. An account of this investigation has been published.

Dr. H. E. Woodman and Dr. J. Stewart have continued their investigations into the role of cellulose-splitting bacteria in the digestion of cellulose. Dr. Woodman has recently published a

monograph on the subject of "Cellulose in Nutrition," and the significance of the results obtained by Woodman and Stewart are brought out in this review.

Dr. H. E. Woodman and his collaborators, Messrs. A. N. Duckham, W. Calton, M. H. French and A. J. Codling, have now completed and published the results of their investigations in connection with sugar beet pulp and molasses beet pulp. During the last year, however, Dr. Woodman, representing the Animal Nutrition Institute, and Mr. Mansfield and Mr. Garner, representing the Animal Husbandry Section of the School of Agriculture, have successfully carried out a large feeding trial, with store bullocks, in which molasses beet pulp was compared with oats. In this work they had the assistance of two post-graduate students, Mr. H. Hirst and Mr. T. Y. Watson. A Report of this work has been forwarded to the Ministry of Agriculture. A similar trial is being conducted at present, in which molasses beet pulp is being tested against dried sugar beet pulp.

In conjunction with Mr. Menzies Kitchin and Dr. R. E. Evans, Dr. H. E. Woodman is beginning a series of trials to test the digestibility and nutritive value of tapioca meal and a new feeding stuff, sago pith meal, in the nutrition of swine.

Dr. R. E. Evans is investigating the nature of the sulphur-containing constituents of grass.

Dr. T. Deighton during the past year has continued his work on the fasting katabolism of pigs of various breeds—Tamworth, Gloucester Old Spot, Middle White, Essex, Wessex and Berkshire pigs have been under experiment. In spring and early summer difficulties arose with the larger calorimeter which caused considerable delay. These have now been overcome and the work is proceeding normally. It had been hoped that it would have been possible to get a new calorimeter installed during the past year at latest. This was to have been built on the principle of the Dewar vessel and was intended for use with lambs, to which work the present instruments are unsuitable. The contract for its construction was given a considerable time ago to a London firm of engineers who specialise in high vacuum work, but after several attempts, some of which were made here, they have at last declared themselves unable to produce the article required, and this project therefore falls through for the present. A project for the erection of a poultry calorimeter, in collaboration with the Department of Poultry Nutrition, is at present under consideration.

Physiology of Reproduction and Growth.—The investigation on the fertility of mares is being continued by Mr. J. Hammond, progress being slow owing to the limited space available for keeping farm animals. Including this year's services (which will be verified by foals produced next spring), the results obtained since the experiment started are as follows :—of 7 mares served late in heat (1–3 days before the end) 6 have been fertile (86 per cent.) : of 9

mares served 4 to 6 days before the end of heat, 4 have been fertile (44 per cent.) : while of 8 served 7 or more days before the end of heat only 2 have been fertile (25 per cent.).

Mr. Hammond has taken further measurements of the muscle, fat and bone in the carcases of cattle, sheep and pigs at Smithfield Show and of bacon pigs at the Dairy Show, in order to provide a basis for a study of growth and the factors affecting quality in meat.

In January, Mr. Hammond proceeded to Trinidad, at the request of the Empire Marketing Board, and during three months (January to March) of the year the inheritance of milk yields and conformation in cattle crosses between the Zebu and the British breeds was studied in Jamaica and Trinidad. A report has been sent to the Empire Marketing Board. Among other results which have a bearing on cattle breeding in this country, the importance and nature of " constitution " as applied to dairy cattle made itself evident ; low milk yields were being produced because of lack of " constitution," even though the inherited capacity of the cow for mammary development was high. Animals with " constitutions " suited to our climate will not necessarily have a good " constitution " in the Tropics.

The stock of inbred strains of rabbits has been maintained for the study of various problems in growth and fertility, and the results derived from these could be applied to farm animals without loss of time when facilities for keeping them become available. Experiments with rabbits and ferrets have been completed which show that the egg must be fertilized soon after it is shed ; otherwise it perishes; in animals which produce many young at birth it has been found possible to produce one or two only as a result of mating late, *i.e.*, just after the eggs are shed. Experiments on the low fertility caused by foetal atrophy (as also occurs in the pig) are being continued with rabbits in which such a strain has been isolated by inbreeding. Foetal atrophy has been shown to be probably a maternal characteristic and not a foetal one, *i.e.*, it is not affected by the breed of the male used.

Dr. A. Walton's experiments on the survival of spermatozoa in gas mixtures of oxygen, nitrogen and carbon dioxide are in progress. An apparatus for measuring such mixtures has been devised and is found to be accurate and reliable. Determinations of the respiratory activity of the spermatozoon in the Barcroft differential respirometer have been made in collaboration with Mr. W. E. Lancaster. This work continues. Experiments on the ascent of spermatozoa in the female passages have also been carried out. Part of this work has been embodied in a paper on the Functions of the Rabbit's Cervix during Coitus. Dr. Walton has been engaged also for a great part of his time in assisting Mr. Hammond, the work being financed by the Empire Marketing Board.

Dr. H. G. Sanders has been proceeding with his work of collecting details for an analysis of the causes responsible for the " Wastage " of dairy cows and interesting results have been obtained. The first

year's returns—to September 30th, 1929—have been analysed, and show an average milking life of approximately five years (based on 2,462 cows sold); the cows sold are not a fair sample as the average length of time they remained in the herds was only two-and-a-half years; thus there is a fairly stable population whose milking life averages approximately six years and a smaller population of cows only temporarily in the herds. The chief cause of disposal was Sterility, which accounted for 23·72 per cent. of the total wastage, and this was followed by Low Milk Yield (19·62 per cent.) and Trade (17·42 per cent). As yet no "herd management" factor has been found to have any significant effect on the wastage, nor is there any marked difference between breeds.

Mr. H. Catchpole has been investigating the growth of living tissues *in vitro* with a view to testing the effects upon cell activity of certain of the internal secretions of the sex organs. Mr. Catchpole also carried out a number of pregnancy tests on domestic animals making use of the urine obtained at different stages of pregnancy. In August, Mr. Catchpole proceeded to the University of California, U.S.A. to study under Professor H. M. Evans.

Dr. G. Pincus (National Research Council Fellow, who spent seven months in Cambridge on a visit from Harvard University, U.S.A.), carried out a research on the early development, *in vitro*, of the rabbit's egg, both fertilised and unfertilised. The actual changes which occur in the segmentation of the egg, both fertilised and unfertilised, were observed, and films and valuable records were obtained illustrating a fundamental biological process. That the mammalian egg could undergo a marked degree of development *in vitro* is a new discovery and opens up considerable possibilities in the future. This work was carried out partly at the Strangeways Research Laboratory, as was also Mr. Catchpole's.

Poultry Nutrition.—Digestibility studies on the commoner poultry feeding stuffs have been continued by Mr. E. T. Halnan. During the period under review, the digestibilities of bran, coarse and fine middlings, and molassed sugar beet pulp have been determined. Judged on the digestible nutrients, wheat offals appear to vary considerably. Bran possesses a relatively poor digestibility, whereas fine middlings is an extremely digestible product. Coarse middlings occupies an intermediate position between bran and fine middlings. On a digestibility basis, bran is a relatively dear food.

The results obtained with molassed sugar beet pulp indicate that this material is unsuitable for use as a poultry feeding stuff. The digestibility figures obtained show an extremely low utilisation of nutrients as compared with the results previously reported for other farm animals.

Dr. E. M. Cruickshank has continued the study of the physiology of fat metabolism in the growing bird and the laying pullet, and has, in addition, accumulated data relative to the seasonal variation of the weight of the thyroid and its iodine content. Evidence has been

obtained showing that, so far as the liver is concerned, a small but definite quantitative increase in fatty acids occurs as the pullet reaches the egg-laying stage. Preliminary indications of a change in the nature of the fat deposited in the egg yolk as the result of variation in diet have also been obtained.

The work carried out by Dr. Cruickshank has, to a large extent, been financed by grants supplied by the Empire Marketing Fund.

The main facts of economic importance resulting from the work on poultry nutrition carried out at the Institute have been written up in popular form by Mr. Halnan, and appear in Ministry of Agriculture Bulletin, " The Scientific Feeding of Animals."

Swine Husbandry.—Mr. A. W. Menzies Kitchin has carried out experiments to determine the economy and effect on quality of carcase, of various feeding stuffs. In one experiment, a comparison was made between rations containing sago pith meal, tapioca root flour and barley meal. No significant difference in result was observed between barley meal and tapioca flour. Experiments with sago pith meal are being continued.

In a further experiment to ascertain the effect of additions of " diamalt "—a vitamin D preparation—and malt and cod liver oil extract to rations of fattening pigs, when the animals selected were initially healthy, no advantage was derived from the use of either preparation. When diamalt was fed to a group of animals which, on selection showed signs of mal-nutrition, a distinct improvement in general condition was observed.

In a further series of experiments the effect of (*a*) a definite storing policy, (*b*) protein deficient rations, on cost of production, growth rate and carcase formation was investigated.

During the year a further report on the East Anglian Pig Recording Scheme was published.

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31. ROWETT RESEARCH INSTITUTE, ABERDEEN.

Progress continues to be made with the investigations reported upon last year. Work on some of the main lines of research has now been completed, and the results in some cases published. Further experimental work is now in the direction of extending present investigations rather than initiating new lines of work. Developments along these lines are briefly indicated below.

BIOCHEMISTRY DEPARTMENT.

(*a*) *Pasture Investigation.*—Work on this investigation which has now been running for several years has been completed and the information sought has been obtained. Practical application is now being made, under different local conditions, of the results of the investigation.

Work of a similar nature to what has been done at this Institute is now being done in each of the Dominions and in some of the Colonies. There appears to be no new problem warranting original research on the part of this Institute, which is interested only in the nutritive qualities of different type of pasture. The pasture investigation will now cease therefore to be one of the main lines of work at the Institute. Any further work done here will be subsidiary to the work at Aberystwyth with which, during the past three or four years, the Institute has been closely associated. The application of the results of the research on pastures will, however, continue to be carried out on the Duthie Experimental Farm, working in conjunction with other similar Institutes.

(*b*) *Influence on Nutrition of Inorganic Traces.*—A study is being made of the influence on nutrition of certain inorganic substances which are present in the animal body or in foodstuffs in relatively small amounts. The elements under study are iodine, aluminium, manganese and copper.

The work on the feeding of iodine to different classes of stock has been continued with dairy cows only. No definite effect was noted on the addition of iodine to the ordinary rations of either pigs, sheep or poultry. In the case of dairy cattle there is an indication of a slight increase in yield of milk from cows receiving extra iodine, and it was noted that the animals in the iodine group appeared to remain in better health than those in the control group. This experiment with dairy cows is therefore being continued to verify this result. Work on aluminium, which consisted in analyses of foodstuffs and animal organs and of feeding experiments with pigs, has been completed and the results published. These show that the feeding of fairly large amounts of aluminium to pigs had no harmful effects on growth or metabolism. Aluminium appeared to be absorbed from the intestine in only very small amounts.

Work on manganese has shown that while plants contain fairly large amounts of manganese, concentrated chiefly in reproductive organs and seeds, the addition of manganese to the ration of pigs had no definite effects on either growth or reproduction. It is evident therefore, that the animal requirements for both aluminium and manganese are satisfied from the amounts contained in ordinary rations.

(*c*) *Composition of Foodstuffs.*—Data continue to be accumulated on the mineral content of foodstuffs, including those used in human dietaries.

PHYSIOLOGY DEPARTMENT.

(*a*) *Nutrition and Disease.*—Arising out of the earler work on mineral metabolism, in which it was noted that animals on deficient diets appeared to be highly susceptible to pulmonary infections, and of the work on pastures, in the course of which it was noted that the incidence of disease in sheep was high in areas where there were

marked deficiencies in the herbage, an extensive investigation has been undertaken on the influence of nutrition on susceptibility to certain infectious diseases. Attempts are being made to correlate deficiencies in the diet with abnormal conditions in the blood which can be determined by chemical analyses and serological tests. A sheep farm in Argyllshire on which there is a high mortality, and on which malnutrition or under-nutrition is known to occur, is affording clinical material for this investigation.

(*b*) *Digestion.*—Factors affecting the movements of the intestine and the absorption of certain nutrients are being studied. The introduction of an X-ray apparatus has enabled these studies to be extended to the living normal animal, and observations are being made on the ruminant.

(*c*) *Avian Physiology.*—A systematic chemical and histological examination is being made of blood and tissues in the domestic fowl, through its life cycle, to ascertain whether the onset of laying, moulting and decreased egg yield in the second and subsequent years of laying can be correlated with any observable changes in any of the organs.

(*d*) *Metabolism.*—The rôle of carbohydrates in nutrition is being investigated, particularly by studying the behaviour of animals fed on various diets to the effects of insulin and other agencies affecting the blood, sugar and the formation of glycogen. Studies have been completed on experimental diabetes in pigs.

(*e*) *Human Nutrition.*—The investigation on the seasonal variations in the rate of growth of school children and the dietary survey in the seven largest towns in Scotland has been completed It was found that a much more rapid increase in height in the children took place from the end of March to the end of June than in any other period. The weight increase was greatest from July to September. As regards the dietaries in the households from which the children were drawn it was found that, when considered from the point of view of adequacy for growth, they were deficient in protein, calcium, phosphorus and iron. This result agrees in the main with results of an investigation of a similar nature carried out in the U.S.A. It is probable that, under the supervision of the Medical Research Council, the data from previous dietary surveys done in this country will be worked out at one of the Medical Schools on the lines of the survey done here.

The survey in England to determine whether the incidence of endemic goitre could be correlated with a low iodine intake in the food, has been completed. The results are inconclusive.

PATHOLOGY DEPARTMENT.

(*a*) *Iron Deficiency.*—Work has been continued on Iron Deficiency. The absorption, excretion and internal metabolism of iron has been studied, and some of the results obtained have been published. The investigation of this subject is being continued.

(*b*) *Anaemia, Leukaemia, etc.*—The inquiries into Iron Deficiency in pigs opened up many avenues for research in regard to anaemia and allied diseases. Thus the embryology and development of the blood-forming tissues, which lies at the root of all blood work; the essential nature of various types of anaemia, of leukaemia and tumours arising from blood building tissues; the basic nature of tumour formation itself; the characteristics of the Van Den Bergh reaction, and the relationship of the alkaline reserve of the blood to this test and to anaemia itself; the therapeutic action of liver and liver extracts on various anaemias and the mode of standardisation or assaying of the potency of liver extract; the essential nature of the action of chloroform as an anaesthetic and in chloroform poisoning; and the fundamental structure and possible function of the suprarenal cortex have been studied and corresponding papers published. Several of these subjects are still in process of further investigation.

DUTHIE EXPERIMENTAL STOCK FARM.

(*a*) *General.*—The last of the new buildings, the byres and sheds for beef cattle, were completed in July. The Stock Farm can now be regarded as established.

(*b*) *Experimental Work.*—The main work for the first two or three years is the getting of all the departments on to the best possible basis with regard to the nature of the stock, methods of feeding and management, and the working out of rates of growth and production and costs under, so far as is known, the most efficient methods. The data accumulated, in addition to being of considerable economic interest, will enable the staff to establish a base line, showing costs in efficient stock husbandry according to present methods. This will be a standard to measure the success or otherwise of attempts to apply new scientific knowledge to the industry.

Two years' records of this kind for the Pig Department have been completed and the results written up for publication. It is hoped that similar records will soon be available for the Poultry and Sheep Departments. In the Dairy Department the work has been upset by an outbreak of contagious abortion.

In addition to the above work, which is regarded as being of the first importance in the meantime, a certain amount of experimental work has been done in all the Departments. Further experiments will, to a large extent, be based upon the fundamental research work carried out in the Institute.

32. (CHEMICAL AND) ANIMAL NUTRITION DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

Poultry Nutrition.—Further feeding experiments with growing chicks have been carried out. In one experiment it was demonstrated that chicks fed on a ration containing 2 per cent. of a high class cod liver oil, with separated milk to drink, could be reared satisfactorily indoors behind ordinary glass, while chicks treated in a similar manner but without the addition of cod liver oil were practically wiped out by rickets. In a third group the conditions were the same as those for the second group, apart from the fact that the window glass was substituted by a glass transparent to ultra-violet light. This did not prevent the onset of rickets, but the attack was less severe than that of the corresponding group behind ordinary glass. Interesting results were obtained from an experiment designed to obtain information as to the relative value of the various ingredients of the mineral mixture used in former experiments. The results showed that the proportion of steamed bone flour in the mixture was unnecessarily high, and further, that the omission of chlorides from the mixture was attended with disastrous results. Not only was the mortality very high, but the chicks receiving no chlorides in the mineral mixture exhibited depraved appetitites and tendencies to cannabalism.

Laying experiments to determine the effect of rearing on subsequent egg yield have been carried out, and an experiment is in progress in which the possibility of including a high proportion of ground home-grown oats is being explored.

Early in the year a preliminary investigation was undertaken with the view of determining the balance of calcium and of phosphorus in mature pullets prior to and at the commencement of laying. The results proved very interesting, and a further balance experi ment is in progress to amplify the results already obtained.

Baby Beef.—Two feeding trials with baby beef have been carried out during the year. In the first experiment no significant difference in liveweight increase was found between two groups of calves fed on similar rations, but which differed as regards dry matter content. The second experiment confirmed the results of a former experiment noted last year, in which a ration containing a high proportion of home-grown foods (low protein) gave as good results as a ration made up largely of purchased cakes.

Composition of Milk.—Reference was made in last year's report to work in connection with the variations in composition of the milk from dairy cows. The collection of data has been completed, and the latter are being examined statistically.

Effect of Sire on Milk Yields of Progeny.—An examination of the records to provide information as to the effect of Registered

Dairy Bulls on the milk yields of Registered Dairy Cows is in progress. It is proposed to make this investigation continuous, so that information relating to sires still in use may be available at the earliest possible moment, and prepotent sires identified and retained.

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33. PIG HUSBANDRY EXPERIMENT STATIONS.

A. Harper Adams Agricultural College.

Feeding Value of Dried Sugar Beet Pulp.—It was found possible to include dried beet pulp satisfactorily in pig feeding rations up to the extent of about 20 per cent. of the total ration. Beyond this point the rations were too bulky for convenient feeding and were inclined to be unduly laxative. Provided the ration were suitably balanced as to protein supply, the dried beet pulp proved equal in feeding value to sharps. Feeding thrice daily was necessary to secure adequate consumption of the beet pulp rations.

Mineral Supplements to Cereal Meals.—Two experiments gave closely concordant results indicating that the only mineral supplements required with a basal ration of cereal meals (sharps, barley, tapioca) were lime and salt. Addition of bone flour proved valueless. Omission of salt caused a very marked retardation of growth.

Economic Value of Potatoes in Pig Feeding.—Varying proportions of cereal meals (barley and tapioca) in a standard feeding ration were replaced by boiled potatoes at the rate of 4 lb. potatoes for 1 lb. cereal meal. The proportions of cereals replaced in different lots were respectively one-third, two-thirds, and the whole. The rates of growth with the low and medium proportions of potatoes did not differ much, but entire replacement of the cereals by potatoes caused a definite retardation of growth. This was in large measure due to the difficulty of securing full consumption of the rations. The economic returns for the potatoes used were greatest where they were fed in small doses. Under these conditions the value realised was assessed at 109s. 0d. per ton, and for the medium allowance of potatoes at 57s. 0d. per ton.

Economic Value of Separated Milk fed in Small Allowances.—The allowances of separated milk to two lots of pigs were at the rate of one pint and two pints per head per day, respectively, these being given in addition to a " balanced " ration of meals. Distinct increases of live-weight were obtained even with the smaller allowance, and the ultimate results showed a return for the separated milk of 6·5d. per gallon when fed at the one pint-rate, and of 5·2d. when fed at the two-pint rate.

Economic Value of Separated Milk at different Stages of the Feeding Period.—With three lots of pigs, about 13 weeks' old, separated milk at the uniform rate of 2 pints per head per day was fed for six weeks, twelve weeks and eighteen weeks respectively from the

start. The feeding otherwise consisted of a " balanced " ration of meals. The continuance of milk-feeding after the first six weeks gave very little extra return, but final conclusions are suspended until the experiment has been repeated.

Normal Growth Rates of Large White Pigs.—The data as to normal growth rates are being steadily increased, and now comprise complete records for nearly 400 pigs.

B. South-Eastern Agricultural College.

It was found during the period November to May that gilts kept indoors and let out to graze during the day when conditions were suitable made the same growth as did those kept on the out-door system.

The protein requirements of an in-pig sow were estimated to be not more than 0·6 lbs. digestible protein at the beginning and 0·7 lbs. digestible protein per day at the end of the gestation period. This estimate was checked by a study of the rations in use on a large number of farms and by a trial at this centre. During the summer normal litters were produced by sows with a free range on grass receiving a cereal mixture containing 0·3 lbs. digestible protein per day.

Observations made indicate that the indiscriminate feeding of mixtures containing a comparatively high proportion of foods rich in protein (such as fish meal) to sucking pigs is liable to cause the young pigs to scour, *particularly when the young pigs first start to eat.*

Post-mortem examinations of piglings made by the Veterinary Research Department indicated that navel infection had taken place. They suggested that this might be prevented by keeping the pens well littered and dressing the navel at birth. These measures were adopted and no further cases have occurred.

The Veterinary Research Department have examined a number of piglings whose teeth had been broken off at birth to prevent them damaging their litter mates when fighting. They report " that considerable damage is caused to the piglings in breaking off the teeth and by the jagged edges of the broken teeth, and that this damage is more serious than the wounds inflicted by the piglings upon one another when fighting."

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34. NATIONAL INSTITUTE OF POULTRY HUSBANDRY, HARPER ADAMS AGRICULTURAL COLLEGE.

Commercial experiments in the production of table poultry, table eggs, ducks, turkeys and geese, are in progress at Newport. During the past year studies have been made in battery brooder operation and its relation to table poultry and egg production. These studies are being continued on an enlarged scale this year. A study of two levels of protein in a mixed protein ration during

the first four weeks of age showed no significant difference in favour of the more costly high protein ration. A study was made of the comparative rate of growth of cockerels, capons, and pullets of the Brown Sussex × Light Sussex cross, primarily to get information on the economics of capon production. All the birds in the studies to date have been used as well in a comparison of trough feeding versus trough feeding and cramming, and also of crates and batteries for fattening table poultry.

A statistical study of egg weights and the relation between egg weight and production factors is being made.

Fish meal and meat and bone meal are being compared for egg production in White Runner ducks, and barley meal and Sussex ground oats for fattening Aylesbury ducklings.

Some preliminary studies have been made of the quality of eggs and a report made of an incubation study involving some of the possible causes of " dead-in-shell."

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35. SMALL ANIMAL BREEDING STATION, CAMBRIDGE.

A new light breed of poultry, the Cambar, was established. Its peculiar feature is the distinction in the down of the sexes at hatching.

A sex-linked down character—the first—was discovered in ducks. Further progress was made on the inheritance of fecundity in poultry. An account of these experiments to date appeared in the Conference Papers of the 4th World's Poultry Congress, Sect. A, No. 7, pp. 37–41.

Further progress was also made with the experimental investigations on fecundity in rabbits.

Exhibits, illustrating the work with poultry and with rabbits, were staged at the 4th World's Poultry Congress.

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36. ANIMAL BREEDING RESEARCH DEPARTMENT, EDINBURGH UNIVERSITY.

During the year under review the Department's new building became fit for occupation, and in June the transference from the Chemistry block was completed. The greatly increased accommodation will make its beneficial influence felt in the future, and already further extension of the Department's activities has been made possible, both by their transference and by the generosity of Mr. T. B. Macaulay, LL.D. To him the Department are indebted for munificent gifts which have enabled them, amongst other things, to purchase the farm of Shothead, Balerno. The farm has hitherto

been run as a dairy farm, and it is proposed in the meantime to continue this practice. Later, when full endowment has been obtained, it will be changed over to an experimental station pure and simple.

Sheep.—As in previous years much work has been done in co-operation with farmers throughout Scotland and England, and our gratitude to our co-operators cannot be too strongly emphasised. Indeed, it is no exaggeration to say that without their help it would have been impossible to attempt much of the practical work which has been carried out by the Department. In particular this applies to our activities in the realm of sheep research. Numerous Blackface sheep owners have placed records of the matings of upwards of 150 picked rams and of the lambs sired by them at our disposal. With these data it has been possible to continue work on the inheritance of face pattern and its possible correlation with milk yield, quality of wool, amount of kemp, hardiness and black fibres in the fleece. This work was begun in 1929, and preliminary results point to there being a definite correlation between face colour and black spotting. There are indications also of a relationship between the amount of white in the Blackface ewe's face and the rate of growth of the lamb. To confirm the results of the preliminary studies further work on the same lines is being undertaken.

The statistical examination of the component fibres of the Blackface fleece, which was commenced in 1928, has been completed. It has been found that wool occurs in the fleece to the extent of 73·5 per cent. by count, 42 per cent. by weight ; long hair 20 per cent. by count, 52 per cent. by weight ; and kemp 6·5 per cent. by count, 6·0 per cent. by weight. Wool is the least variable portion by weight and count. The long hair is more than twice as variable and kemp is variable to an extraordinary degree. As improvement of livestock depends upon the occurrence of variation, it would appear not impossible to breed out kemp from the fleece.

Within the Department work of a more purely physiological nature has been carried out. The results of an examination of the claims of Voronoff seem to indicate that it is inadvisable to continue the investigation further. The presence of a gonad graft in the immature ram results firstly in a decrease in metabolism, as judged by periodic recordings of the body weight. This phase lasts approximately 10 weeks. Thereafter, for some 30 weeks, the grafted individuals grow at a rate faster than that of the controls. This is succeeded by a third and final phase when the stimulating effect of the grafting operation diminishes and the slower but more regular growing controls gain on the grafted individuals and eventually surpass them in weight and size.

An examination of the effects of thyroidectomy upon the Blackface appears to show that this operation causes a change in the characterisation of the wool. This change can best be expressed as a decrease in the total number of fibres per unit area of the skin, a

marked decrease in the cross-sectional area of the individual heterotype fibre, a decreased tensile strength and elasticity and a cessation of the growth of the kemp. The Department does not possess the special apparatus required for determining tensile strength and elasticity so that the latter findings cannot be taken as final. Arrangements are being made, however, for the co-operation of the Wool Industries Research Association, and when these are complete a detailed physical and chemical examination of wool from thyroidectomised sheep will be carried out.

Rabbits.—Opportunity for the study of the genetics of the rabbit has been greatly extended by means of funds provided by the Development Commissioners. During the year 1929-30 a grant of £530 was made to the Department, and a further sum for capital expenditure has been guaranteed by the National Rabbit Council. This sum has been raised by subscription among the breeders, fanciers and manufacturers throughout the country. The main subject of study during the preceding years was the Angora Rabbit and the wool which it produced. Now, however, much work is being carried on with fur bearing varieties. Since the work is planned to be of use to the practical breeder as well as to the scientific man, Rabbit Husbandry in its widest scope is being studied. Purely genetical studies of the Argente, the Chinchilla and Chinchillated varieties are being made and the inheritance of furlessness is being examined. An examination of the different types of fur and their inheritance was commenced early in 1930 and the effects of special feeding, temperature, and castration upon the coat qualities are being observed. In addition a variety recessive in as many characters as possible is being evolved. It is felt that such a variety would be of very real value for testing purposes.

Cattle.—The study of the inheritance of milk yield in dairy cattle continues, but progress is necessarily slow owing to the great amount of data which must be analysed statistically. So far as the study has proceeded all the evidence seems to confirm the original indication that total yield is inherited in a sex-linked manner. This, however, does not appear to be the case as regards yield of butter fat.

Pigs.—The first Annual Report of the Pig Testing Station was issued in July. It was the aim of the workers engaged in this station not only to trace the inheritance of those qualities of the pig which make for efficient bacon production, but also to correlate this with disease, nutrition and economics. The Station has been working to its fullest capacity throughout the year and has been the means of demonstrating to breeders of pedigree pigs the direction in which their present methods are leading them. This has led to the production of a better type of pig and in turn to a demand by other breeders for pigs related to those which have proved themselves of first class value at the Testing Station.

The success of the Pig Testing Station has had an unfortunate effect on other work undertaken with this animal as the subject of study. The Station has taken up the greater part of the available accommodation, and for this reason it has been impossible to enquire fully into the comparative merits of purebred and crossbred animals as economic bacon producers. It is hoped, however, that this work and work of a similar nature will be developed more fully in the future.

Horses.—An extensive experiment was started early in the Summer of 1930, which has as its ultimate aim the establishment of a pregnancy test for mares. Difficulties, some foreseen and some quite unexpected, have inevitably cropped up, but they are all being overcome, and although the experiment is yet in its earliest stages it does not seem unduly optimistic to anticipate its ultimate success.

Poultry.—The domestic fowl has proved ideal material for the study of sex physiology. Much of the work done with these birds has no direct bearing upon the problems of poultry husbandry, but has been planned and carried out with a view to examine the endocrine function of the gonads and of the thyroid and thymus ; but one study of immediate practical value as well as of scientific interest was made during the year under review. Eggs of abnormal size, shape and consistency were examined. It was found that the bird which lays the largest normal egg also lays the largest abnormal, and this applied not only to the hen but also to ducks, geese and turkeys. The abnormal eggs examined, numbering a hundred, were readily divisible into two groups according to shape, one group being a diminutive replica of the ordinary egg and the other much more cylindrical. The former was much the more common, and in sixty-five out of the total ninety-one of this group, yolk was present either surrounded by membrane or lying free within the albumen. It appears that the size and shape of all eggs is dependent on the size and shape of a central mass which, in the normal egg is the yolk and in the abnormal either yolk, inspissated albumen or blood clot.

Other studies in poultry include the genetics of plumage colour in the old English Bantam, the Duck and the Turkey ; the physiology of broodiness ; an observational study of sex-reversal and sterilisation by X-rays, but these are still incomplete.

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37. (CROP AND) ANIMAL HUSBANDRY DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

The Production of Early Maturing Beef.—A number of experiments in connection with the production of early maturing beef have been carried out during the last three years. Various problems in connection with feeding have been investigated by the Animal

Nutrition Division and a statistical examination of the results from these feeding experiments has been made by this Division and is now ready for publication. Different systems of rearing, management and disposal of the calves have been studied and a report is in course of preparation describing these systems and their results, together with all details of liveweight gains and cost of production.

H.

DAIRYING.

38. NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING.

In last year's report it was stated that " Important work is now being carried out at this Institute under the auspices of the Empire Marketing Board with the collaboration of the Dominions Overseas. It seems fitting that some account of this work should be given this year as much has been accomplished, both by the members of the staff itself and by the visitors we have had with us—Dr. G. M. Moir from New Zealand, and Mr. W. J. Wiley from Australia.

Dr. Moir came to this Institute three years ago as a voluntary worker, but after a year at the Institute he obtained the First Pedlar Research Scholarship under the Pedlar Research Committee of the Institute of Chemistry, which enabled him to remain for a further two years. During that time he studied the chemical changes which are produced in milk by heat. Mr. Wiley's visit was made possible by the Council of Scientific and Industrial Research of the Government of Australia.

Effect of Heat on Milk.—Dr. Moir was led to investigate the effect of heat on milk because of the widespread use of pasteurised milk for Cheddar cheese-making in New Zealand. Following up the work which Dr. E. C. V. Mattick and H. Hallett had been conducting on the influence of heating milk upon coagulation by rennet, and upon the ratio of diffusible to indiffusible lime salts, and work by other authors, including that of Benson and Evans, Dr. Moir proceeded to study pasteurisation by the " flash " process at 165° F. for which he devised a special apparatus. He selected two types of milk for his experiments, clean milk and a market milk typical of ordinary pasteurisation of clean milk at 165° F. produces very little change in it compared with similar treatment of market milk. The changes produced in the clean milk at 185° F. are more comparable to those produced in market milk heated to 165° F. He particularly noted a decrease in the whey nitrogen which was associated with an increase in the coagulation time with rennet caused by pasteurisation.

The effect of " starter " on pasteurised and raw clean milk was also studied and a comparison of the wheys obtained by rennetting showed that those from the acidified milk contained more soluble protein than the original. Cheese were made and analysed from milks treated as above. These researches directed Dr. Moir's attention to the need for more exact methods for the determination of the milk proteins casein, globulin and albumin, and as one result of these researches he adopted the suggestion that casein* be defined as the material which is precipitated from cows' milk at a pH 4·6

* Dr. Moir in his work used the Continental and American terms—casein and paracasein—instead of caseinogen and casein frequently used in the English literature. The first term in each case signifies the base-free protein as normally obtained from milk by acidifying while the second is applied to the modified base-free protein obtained by the action of rennin on milk.

by acetic acid buffered by sodium acetate, a conclusion founded on the fundamental basis of the conception of the isoelectric point. Dr. Moir then studied methods for the estimation of albumin and globulin, either by precipitation of the casein and globulin by neutral saturated magnesium sulphate or sodium sulphate, and the determination of the albumin by the precipitation of the total protein by warm 4 per cent. trichloroacetic acid. These methods, however, he regarded as defective and agrees with Howe that until independent procedures are devised for the identification of the proteins, " salting out " must remain as the point of departure for future work.

Dissociation of Calcium Citrate.—Mr. Wiley came to us with the intention of studying the acid base ratio in milk, concerning which some statistics were already available which demonstrated the variability of the titratable acidity of milk from different sources, and its influence on rennetting for cheese making. Owing to the fact that Mr. Wiley was compelled to return to Australia before he had completed his studies he was unable to carry out that full scheme of research which he had planned. Nonetheless, he was able to publish a paper upon the " Dissociation of Calcium Citrate " in milk which led him to believe that the statement that the addition of a citrate to milk prevents clotting by rennin because an un-ionised calcium citrate is formed which removes from solution the calcium ions considered to be necessary for the clotting process, did not explain the phenomenon completely, since his work appeared to show that even after the addition of citrate there are sufficient ions to allow the clotting process to take place.

Taints due to Oxidation of Milk Fat.—These taints, which are variously described as oiliness, tallowy flavour or fishiness, are found to occur in milk and butter and the problems which they present are both bacteriological and chemical.

The bacteriological studies of this subject have now been completed and reveal the fact that the seasonal prevalence of oiliness particularly, is due chiefly to the flora of the milk acting in the presence of small traces of one of the heavy metals, especially copper. The flora may be divided into two main groups, those which tend to produce high acidity and those which do not do so. In the former group, organisms of the type of *S. Lacticus* and *B. Coli* are included ; in the latter, yeasts and chromogenic cocci form characteristic types. These latter grow at fairly low temperatures (at which oiliness occurs) and can withstand considerable concentrations of copper without inhibition. Acid producing organisms, on the other hand, require higher temperatures for satisfactory growth. This fact explains the predominance of low acid-producing organisms in oily milk and the tendency of this fault to be most marked during the winter season. During the summer the temperature conditions favour the proliferation of acid producing organisms and " oiliness " does not appear. If, however, the flora consists of non-acid

producers, " oiliness " will occur at any temperature provided that the flora does not reduce the oxidation reduction potential below a certain figure.

By measurements of the oxidation-reduction potentials induced in milk by pure cultures of the various organisms isolated from oily milk at high and at low temperatures and by similar measurements in milk to which copper had been added, it was found that the lowering of the oxidation—reduction potential by the substances produced by organisms of the S. lactis type prevented the oxidation of the fat by copper. The other organisms typical of oily milk did not induce such low oxidation-reduction potentials and did not, therefore, inhibit the oxidation of fat. It is, therefore, important to exclude metallic contamination from milk, especially that which contains only small numbers of non-acid producing organisms, viz., clean milk.

Further investigations of this problem have been carried out in order to study the effects of small traces of metals on the speed of auto-oxidation of butter-fat. The methods used in the study have been (*a*) determining the lengths of time necessary to give a fishy and tallowy taste, (*b*) lengths of time to give positive aldehyde reactions, (*c*) concentration of substances oxidisable by permanganate with length of time, (*d*) concentrations of the intermediately-formed peroxide with time of keeping, (*e*) potentiometric observations of butter and butter fat suspensions under varying conditions of oxygen tension.

During the past year most of the work has been upon sections (*d*) and (*e*), and results verify previous findings, namely, that traces of metals (working in the range 1 to 10 parts per million) accelerate the formation of peroxides and that activation of oxygen occurs in their presence. Oxygen activation has also been studied by examining the behaviours of oleic acid, and lecithin in salt solutions (among others) in contact with oxygen. These compounds caused activation of dissolved oxygen when aerated, the concentration of " active oxygen " being maintained during the process of aeration. A decrease of concentration was immediately observed on cessation of aeration which showed that the active oxygen was being used up for oxidative purposes.

The " fixing " of ionic copper by milk proteins has been studied under different conditions of milk acidity. Increasing hydrogen ion concentration in milk (decrease in pH) caused less fixation of copper by the proteins. The minimum fixation occurred about pH 4·6 to 4·8. This pointed to the fact that the combination of copper with milk proteins was least at the isoelectric point of casein.

Some work has been done on the effect of strong sunlight as an activator of dissolved oxygen, since this has been known to give rise to " sunlight taint " in milk which is, in fact, a reaction similar to that which has been already described and is due to the rays passing through clear glass.

Red Spot in Cheese.—During the past year, four papers have been published on this subject, these set out the cultural characteristics and metabolism of the organism which is responsible for this fault in English hard cheese and establish its identity. The laboratory work, upon the occurrence and habits of the organism, has led to an attack upon the practical aspects of the problem and has suggested explanations for the apparently anomalous results obtained in the course of experimental and farm cheese making. The cheese making results so far secured, seem to warrant the belief that a solution to the problem of control under practical conditions has been found. This solution has only been made possible by a study of the associated metabolism of the organisms common in milk and cheese, since it has been shown that the colour change is only produced when organisms associated with the specific bacterium have effected preliminary changes in the proteins of the milk upon which the specific bacterium can then act. Thus it is that cheese made from clean milk, even when heavily infected with the specific organism, does not show the presence of " red spot."

This work is not only of value in assisting to eliminate the losses which " red spot " in cheese causes, but has a much wider application since it brings out once more a fact which had already been appreciated, that it is necessary to carry out fundamental research on the associated metabolism of different organisms—a problem upon which some work has been undertaken but much more still remains to be done.

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39. HANNAH DAIRY RESEARCH INSTITUTE, AYR.

I. GENERAL DEVELOPMENT OF THE INSTITUTE.

Considerable progress has been made with the new buildings at Kirkhill, Auchincruive. The farm buildings are practically complete, and a herd of pedigree Ayrshire cattle has been acquired. The new laboratories are in course of erection, and it is anticipated that they will be available for occupation early in the New Year.

II. WORK COMPLETED OR IN PROGRESS.

(*a*) *Tuberculosis in Dairy Cows.*—The survey of the extent and causes of re-infection in tuberculin-tested (licensed) herds has been completed, and a full report is in the press. The summary reveals an average proportion of reactors in licensed herds of 3 per cent. per annum, the proportion varying from 5 per cent. during the first year of testing to 1 per cent. in old-established herds. An analysis of over 450 individual case histories of reactors shows that at least 90 per cent. of these animals obtained infection from avoidable sources, and the results of the survey have enabled the Institute to recommend a number of precautions by means of which such losses may be largely eliminated.

Progress has been made in the experimental scheme of eradication undertaken by the Institute. It is, however, premature to make any definite pronouncement upon the ultimate success of the scheme.

As a result of the examination of existing data on the tuberculous infection of the milk supplies of Scottish cities, which was referred to in the last report, the Institute has been able, in conjunction with the Department of Health for Scotland, to initiate extensive investigations into the infection of the milk supply in different localities, and of milks treated by different methods—raw, graded, pasteurised, condensed and dried. The investigation is being carried out in conjunction with the Local Health Authorities of Edinburgh, Glasgow, Dundee and Aberdeen, and is expected to extend over a period of two years.

(*b*) *Protein Metabolism.*—Work has been commenced on various aspects of the protein metabolism of dairy cows.

Investigations are in progress into the mechanism of secretion of protein in milk, and the results so far obtained confirm the very important function of the free amino-acids of the blood as precursors of milk protein. These investigations are being continued and extended.

The relation of the amino-acid content of foodstuffs to their value for milk production is being studied. At present, work is limited to an examination of rapid methods of analysis, a preliminary step which is necessary before the main investigations can be carried out.

(*c*) *"Constitution" in Dairy Cows.*—A survey of the length of life of cows in milking herds has been commenced in collaboration with the Scottish Milk Records Association and a representative *"ad hoc"* Committee. Data on the chief causes of loss have been collected during the year from a large number of milk recorded herds. It is intended that the survey should be continued for a further period of two years.

(*d*) *Surplus Milk and Milk Residues.*—The collection and classification of literature on the condensing and drying of milk and milk residues has been completed. A detailed summary of the literature is in course of preparation.

Experiments have been carried out on the use of milk and milk products in bread-making, and a paper summarising the preliminary results has been published. Continuation of this work is, at present, prevented by lack of staff.

By co-operation with Professor A. L. Mellanby, D.Sc., of the Royal Technical College, Glasgow, it has been possible to initiate experiments into the engineering and physical aspects of spray-drying. A small scale spray-drier has been erected, and experiments are in progress to determine the thermal efficiency of the drying process under carefully controlled conditions.

During the year Professor E. P. Cathcart, F.R.S., resigned from the position of Honorary Director, and Dr. N. C. Wright was ap-

pointed Director. In addition to Dr. Wright, the staff of the Institute consists of one permanent assistant and two temporary assistants, while three other workers assist in investigations in an honorary capacity.

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40. DAIRY BACTERIOLOGY DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

Research work at this Division was seriously handicapped by the illness and death of the Head of the Division (Mr. George Wilson, B.Sc., M.R.C.V.S., D.V.S.M.).

The work on "starters" initiated last year was continued. It was found that certain types of starters were contaminated with moulds and yeasts, and to this factor was attributed undesirable flavours and odours following their use.

Investigations at certain Creameries showed that a very efficient pasteurisation was being completely nullified by recontamination from dirty cream pumps, ripening vats and churns.

A clean milk competition was conducted by the Division during the year in order to demonstrate that milk of a very high standard could be produced without involving farmers in the purchase of expensive plant and buildings. This competition, which was the first of its kind in Northern Ireland, was very successful. The Division continued to supervise the production of Grade A (T.T.) milk and to advise prospective producers regarding suitability of premises, equipment, etc., also to examine bacteriologically all routine and surprise samples.

Advisory Work.—Increasing use of the facilities provided by the Division was made by Veterinary Surgeons and farmers. Queries and specimens received dealt chiefly with objectionable odours and flavours in milk, cream and butter.

The Division also undertook the inspection and testing of a dairy plant which had been entered for the new inventions class at the London Dairy Show.

I.

AGRICULTURAL ECONOMICS.

41. AGRICULTURAL ECONOMICS RESEARCH INSTITUTE, OXFORD UNIVERSITY.

The Distribution of Agricultural Produce.—In continuation of the study of the marketing of dairy products, under the direction of Mr. F. J. Prewett, the field work of an investigation of production and distribution in West Cornwall has been completed, and the preparation of a report thereon is now in progress. In this remote district economic conditions provide a useful contrast with those of areas of production already examined.

Consumers' Preference.—An intensive study of two important fat stock markets has been made to test the consumers' preference for different grades of meat as reflected in prices.

Economic Agricultural Surveys.—In the year 1923 a general farm management survey of some 200 farms, representing an area of about 40,000 acres, in South Oxfordshire was made. Last year the same area was re-surveyed, under the direction of Mr. R. N. Dixey. Individual reports, based on a comparison of holdings, have been sent to every farmer concerned, and a general report, comparing the two surveys as a whole, is in course of preparation.

Sugar Beet.—This crop has assumed additional importance in general farm economy, owing to the severe decline of cereal prices, and the study of growers' experience and costs of production under various conditions of cultivation, begun in 1924-25, has been continued. The usual annual report on costs, yields and returns was issued by Mr. A. Bridges and Mr. J. R. Lee, and about 1,000 records of crops grown in each of the years 1927, 1928 and 1929 have been received from the sugar beet factories for an analysis of the results of experience in cultivation and manuring.

At the request of the Swedish Legation, a report was prepared for the Swedish Government on the history and progress of the sugar beet industry in England and Wales.

Progress in Farming Systems.—This title describes a series of investigations, begun a few years ago, of achievements in farming practice falling outside traditional routine. Particular attention has been given to enterprises leading to the maintenance of arable farming, which is bearing the brunt of the prevailing depression. Mr. Prewett, with the assistance of Mr. D. Skilbeck, has completed the field work of a study of a large group of small farmers in Cheshire, where milk production on arable land is the principal industry. This work has been done in collaboration with The Cheshire School of Agriculture, under a grant from the Development Commission.

A specialist corn-growing enterprise in Berkshire, unique in its methods, magnitude and success, was investigated by the Director, and a report thereon published.

In another direction, a successful demonstration of upland grazing improvement, on a class of land which extends, probably, to over 1,000,000 acres in England and Wales, was examined and reported

upon by Mr. F. J. Prewett, in collaboration with its originator, Mr. Stanley Bligh.

Factors affecting the Prices of Livestock.—An attempt has been made to discover and measure the relationships of the more important factors affecting the prices of fat cattle, sheep and pigs in Great Britain, with a view to a closer estimation of future price movements. This work has been carried out by Mr. K. A. H. Murray, and a report is now in the press.

Agricultural Atlas of England and Wales.—This Atlas, originally published for the Institute by the Ordnance Survey Department, based upon the *Agricultural Statistics* of 1918, is nearly out of print, and at the request of the Ministry of Agriculture a revised edition, based on the Statistics for 1928, is in course of preparation. This work is being done under the direction of Mr. M. Messer.

Agricultural Economic Research within the Empire.—Under the special grant from the Empire Marketing Board, Mr. J. P. Maxton has made further progress in establishing communications with the research departments of Empire countries, with a view to co-ordinated work. Arrangements were made for a comparative study of the economic factors affecting the production of milk and butter-fat in countries catering for the British market.

A memorandum on the general principles of agricultural cost accounting, as practised in England, was circulated to research institutes in certain Empire countries, which has led to correspondence on methods in use amongst parties engaged in similar work.

A considerable part of Mr. Maxton's time has been spent upon the work of the Economic Research Branch of the Empire Marketing Board.

Analysis of Costs and Financial Records.—Work on the study of farming costs and the analysis of financial accounts has been continued, and results of interest to farmers have been issued from time to time. The co-ordination of work at provincial research centres with that done at the Institute was begun.

In view of the growing importance of the poultry industry, an arrangement has been made with the technical staff of the Oxfordshire County Council for the study of a group of poultry holdings. Mr. A. Bridges and Mr. J. R. Lee are in charge of the work in this section.

Rural Migration.—An investigation of migratory movements amongst the farming population and their causes, is being made by Mr. E. Lorrain-Smith, a research scholar of the Institute.

42. FARM ECONOMICS DEPARTMENT, DEPARTMENT OF AGRICULTURE FOR SCOTLAND.

A report on the profitableness of certain groups of farms characteristic of the North-East, East and South-East and South-West of Scotland is now nearing completion, and is based upon accounts received through the three agricultural colleges from 119 farms for the year 1928–29. It is intended that this should be the first of a series of annual reports upon the economic position of the Agricultural industry in Scotland. Although not yet based upon a representative sample of farms, it is possible to discuss the broader differences in agricultural features, farming personnel, capital and output of the several groups. The returns obtained by farmers and employees for the period under review are considered in relation to the incidence of family labour and to the volume of capital employed; and the factors underlying variations in profits are discussed.

The work on the classification of farms, based on an analysis of the Agricultural Returns, has been completed for the counties of Berwick, Roxburgh, Selkirk and Peebles, and a report on the results of classification in the first three counties has been prepared Classification is proceeding for other areas.

As this classification proceeds, it will form the basis of the selection of sample groups of farms from which to obtain accounts, with a view to interpreting the economic position of large sections of the industry from a study of these sample groups.

Investigations into the organisation of marketing of livestock and potatoes are nearing completion.

J.

PRESERVATION
and
TRANSPORT.

43. DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND UNIVERSITY OF CAMBRIDGE.

Low Temperature Research Station.*

Work in progress during the year ended June, 1930, can be classified roughly under the following headings :—

Section A.—Meat.

The transport of New Zealand frozen mutton and lamb : loss of bloom.
The factor of quality in the freezing of meat.
The physiology of rigor mortis.
The freezing of tissues.
Changes in muscle pigments.
Changes in fats during storage.
Bacteriology.

Section B.—Fruit and Vegetables.

Biochemical study of senescence in apples.
Effect of climatic conditions upon the storage life of apples.
Loss of water from apples in relation to humidity.
Effects of humidity in the storage of apples.
The effects of acetaldehyde on the growth of moulds.
The action of acetaldehyde upon fruit.
The storage life of pears in artificial atmospheres.
The effect of volatile products on the storage life of fruit.
The treatment of the cut stalks of fruit to prevent rotting.
The wastage of fruit in commerce.
Temperature and the wastage of fruit during overseas transport.

Section C.—Pig Products.

The freezing and storage of mild-cured bacon.
The scientific basis of curing.
The effect of sodium chloride on the superficial micro-flora of meat.

Section D.—Biological Engineering.

Rate of evaporation from eggs.
Generation of heat by respiring fruit.

Section E.—Canning.

Substances inhibiting the corrosion of iron.
The corrosion of tin, iron and the tin-iron couple.
The corrosion of tin-plate.
Practical fruit canning.

These subjects are dealt with in detail in the Annual Report for 1929–30 of the Food Investigation Board (H.M. Stationery Office).

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* Report included by courtesy of the Department of Scientific and Industrial Research.

44. FRUIT AND VEGETABLE PRESERVATION RESEARCH STATION, BRISTOL UNIVERSITY.

During the last few years the principal work of this Station has been in connection with the establishment of a fruit and vegetable canning industry along scientific lines. The majority of the subjects under investigation are of practical importance to the canner, and of these one of the most urgent is that of hydrogen swells and perforations produced by corrosion of the cans by the fruit.

Corrosion.

Addition of Acid.—The heaviest losses from corrosive action occur in fruits low in acid, and when canning such fruits it has been found that the losses can be prevented to a certain extent by the addition of a small quantity of citric acid to the syrup. Experiments along these lines have been continued, and strawberries, black cherries, Victoria plums, and greengages have been canned in an acid syrup.

Cane and Beet Sugar.—Experiments carried out on a laboratory scale at Cambridge have indicated that beet sugar contains traces of some substance which inhibits corrosion of tinplate. At the request of the Cambridge workers, practical scale trials have been carried out at Campden, and raspberries, loganberries, cherries and Victoria plums have been canned in cane and beet sugar syrups. These are being stored at 95° F. to accelerate corrosion, and the results from the two sugars will be compared.

Effect of Time of Sterilization.—Gooseberries, raspberries and greengages were canned and sterilized for different periods to ascertain if there is any connection between the length of time of sterilization and the production of hydrogen swells or perforations.

Storage Temperature.—All the common English fruits have been canned and batches of each are being stored at 72° and 95° F., the highest average storage temperatures likely to be experienced in this country and in the tropics. The cans are being examined periodically, and the records will show the effect of high storage temperature on corrosion.

Temperature of Closing.—A good vacuum in the cans is an advantage in that it prolongs the period before the development of hydrogen swells. The vacuum obtained in cans of fruit depends largely upon the temperature at which the cans are sealed. Cans have been sealed at various temperatures, and the effect of the closing temperature on the vacuum and on the formation of hydrogen swells will be noted.

Tinplate.—American-made cans have been tested against English cans to find out if there is any difference between the tinplates so far as corrosion is concerned.

The Exhaust Process.—Experiments carried out in America have shown that the presence of oxygen in canned fruit accelerates corrosion, and as the degree to which the oxygen is removed depends largely on the efficiency of the exhaust process, the following tests were made :—

(*a*) Cans closed under a vacuum of 24".

(*b*) Cans heated in an exhaust box at 190° F. for six minutes.

(*c*) A combination of low temperature exhaust, followed by vacuum closing.

(*d*) No exhaust, but fruit in cans covered with boiling syrup.

(*e*) Double exhaust : the fruit being given a low temperature exhaust to remove air, followed by a high temperature exhaust to give a good vacuum.

A Canners' Bulletin giving the results obtained up to the present in this country and in America was published from the Research Station during the year.

Variety Trials.

Strawberries.—The canning trials on the many varieties of strawberries have been continued, and twenty-five varieties have been tested during the season. As the result of tests carried out over three seasons, the following varieties appear to be most suitable for canning.

Sir Joseph Paxton.—This variety has been consistently good. It is firm and of good shape, colour and flavour.

Oberschlesien.—This berry is the best as regards colour and clearness of syrup. The flavour is also good. There is a tendency, however, for awkward shaped berries, and this is its principal drawback.

Royal Sovereign.—This variety has not been consistently good but some samples have been excellent. The flavour is generally good, but the canned product is often rather pale in colour. When canned immediately after picking this variety is very satisfactory.

The Duke.—In the 1928 season's tests this variety gave a poor product when canned. The fruit was dull in appearance and was inclined to go soft very quickly in the can. The fruit obtained last year canned decidedly better, and one sample canned during 1930 turned out very satisfactorily.

Raspberries.—When considering the quality of raspberries from the canning point of view, attention must be given first to the firmness of the berries, as this fruit is the most difficult to obtain in a firm and dry condition.

Of the varieties which are grown on a commercial scale, Lloyd George is undoubtedly one of the best for canning. It is of good size, is reasonably firm, and the colour and flavour are both good.

Other suitable varieties are : Semper Fidelis and Pyne's Royal.

Duke of Cornwall and Devon produce good sized, firm fruit, but these varieties are inclined to be rather light in colour when canned.

Red Cross, Hornet, Norwich Wonder, Red Antwerp and Profusion are moderately satisfactory but do not come up to the standard of Lloyd George.

Plums.—All the varieties of plums grown on a commercial scale have been canned during the year, and the best results were obtained from the following : Victoria, Yellow Pershore, Purple Pershore, Early Prolific, Blaisdon Red, Early Laxton, Denniston's Gage, Monarch and Pond's Seedling. The two last are, however, generally too large for canning.

Damsons.—Ten varieties of damsons have been tested. The Shropshire Prune gave excellent results, having a rich, purple colour and a marked damson flavour.

The common or English damson and the Westmorland damson, although both on the small side, were fairly satisfactory. They were of a reddish purple colour and the flavour was good.

The Worcester damascene when canned is of a good colour, but the damson flavour is not so marked as in some of the other varieties. At the same time it is quite good and deserves to be canned far more extensively than it is at present.

Bradley's King is rather large for a damson but when canned has quite a good flavour. It is, however, not attractive in appearance, as the skin assumes a dull, brownish-green colour.

The Farleigh damson is small in size, with a comparatively large stone. When canned it is poor in appearance, due to the brownish-green tint of the skin. The flavour is only fair. This variety is not as satisfactory for canning as some of these mentioned above.

Frogmore and Merryweather gave only very moderate results.

Peas.—Extensive tests on the canning of the different varieties of peas have been carried out during the last few years, and we are now in a position to say which are the best for canning. In addition to this it is necessary to know which of the numerous canning varieties will grow best in the district where the cannery may be situated.

During the year under review extensive trials on the growing of several varieties were carried out by the Kirton Agriculturai Institute and the Norfolk Farm Institute and samples of each variety were sent to Campden for canning trials. By collaborating the

results of these tests, information of benefit to the growers and the canners in East Anglia should be obtained.

Analysis of Fruit.

All the common fruits were analysed for acidity, total and invert sugars, and the pH values of the juices were determined.

Absorption of Calcium and Magnesium by Peas.

The absorption of calcium and magnesium by peas during blanching has been determined, using standard hard waters. The action of water of various degrees of hardness is thus being studied.

Vegetables.

Numerous experiments have been carried out on the canning of peas, stringless beans, small beetroot, carrots, cauliflowers and new potatoes.

K.

AGRICULTURAL ENGINEERING.

45. INSTITUTE OF AGRICULTURAL ENGINEERING.

I. World Agricultural Tractor Trials.

The Institute, in accordance with the arrangements noted in last year's report, co-operated with the Royal Agricultural Society of England in these trials. The number of tractors entered was 33 (U.S.A. 12, Great Britain 8, France 5, Germany 4, Sweden 2, Irish Free State 1 and Hungary 1). Three market garden cultivators were also entered (Great Britain 2 and Switzerland 1). A radical departure from the methods adopted in previous tractor trials in this country consisted in subjecting all these machines to definite scientific tests prior to the Public Demonstration. For the purpose of these tests an Electro-Dynamometer was acquired ; the Dynamometer Car previously constructed by the Institute was improved, and a new Dynamometer Car and a Recording Dynamometer were constructed to the Institute's designs. Thanks are due to Mr. J. H. Hyde, of the National Physical Laboratory, for advice respecting these instruments, and to Professor Southwell of this University for affording facilities for calibrating the recording dynamometer. Implements for use with the tractors in the field tests were mostly provided by Messrs. Ransomes, Sims & Jefferies, and by Messrs. J. & F. Howard.

The scientific tests of the tractors were carried out by the staff at the Institute, between June 2nd and July 26th, at Crowmarsh Battle Farm (Mr. F. P. Chamberlain), near Wallingford. The Market Garden Cultivators were tested in May in the Evesham district. A full illustrated report of the tests was prepared ; of a first edition of 3,000 copies some 1,700 were sold at, and the remainder within four weeks of, the Public Demonstration. This was held on September 16th to 19th on land at Ardington, near Wantage, for the use of which thanks are due to Mr. A. T. Loyd. It was largely attended by visitors from all parts of the country, and from abroad. All the arrangements met with very general approval.

The trials fully achieved their object of providing comparative figures of performance of a wide range of tractors and of showing them at work. A noticeable feature was the number of tractors of British manufacture with Diesel engines—a comparatively recent development.

The value of the trials from a scientific point of view lies chiefly in the suggestions afforded for further investigation. For example, the observations on wheel slippage would seem to suggest that further research on tractor wheel design might usefully be undertaken. The measurements of dilution of crankcase oil suggest that the question as to what extent this is detrimental might profitably be followed up.

II. Research.

(*a*) *Dehydration of Crops and Products.*—(1) *Crop Drying.*—Work on this has been gradually relinquished by the Institute and

is being left to commercial development. It may be noted that a conveyor-belt dryer, of a somewhat similar design to that referred to in last year's report, has been used to dry combine-harvested grain.

(2) *Grain Drying.*—A grain-dryer on the lines of that described in the Institute's Bulletin No. 3, for use in connection with combine harvesting, was constructed by a private firm and exhibited at the Royal Show at Manchester. It was subsequently installed on a farm in Hampshire and used to dry combine-harvested grain. Another dryer on similar lines was privately built and similarly used in Lincolnshire.

The Institute assisted at trials of combine-harvesters, which were held by the Ministry of Agriculture, by lending its grain dryer and taking observations of moisture-content. The crops generally were short in the straw, and the undergrowth of clover and weeds high, so that, although the weather at the time was very favourable, bulk samples straight from the combine showed a high percentage of moisture. This was considerably reduced by subsequent dressing, and in most cases it was not necessary to dry the grain.

The use of a combine calls for a quick routine method of moisture-testing, a matter which is receiving the attention of the Institute.

The Institute dryer was subsequently used to dry mangel seed : in this case it was found advisable to dispense with the elevating and discharge mechanism and use the dryer as a " batch dryer." This method holds out promise of a simplified and much cheaper dryer, which can be driven by a stationary engine of only 2–3 h.p.

(*b*) An experimental crop of flax was, at the request of the Ministry of Agriculture, sown at Pin Farm. Unfortunately the weather interfered too much with the harvest to allow of any useful conclusions being drawn as to the comparative value of cutting and hand pulling as methods of harvesting. A flax-pulling machine was employed and did good work.

(*c*) *Electricity in Horticulture.*—At the instance of the Ministry of Agriculture, Mr. C. A. Cameron Brown, towards the end of 1929, visited France (Paris and Lyons) and Germany (Rhine and Moselle districts) to study the use of electricity in market gardens and vineyards. In France electricity is not much used in either. Light electric ploughing sets have been tried, but their use has not become at all general. Electricity has also been employed for the heating of greenhouses, but the cost of power has prevented development. In the Rhineland, though conditions favour electrical cultivation, engine-driven sets, owing to their lower cost, are everywhere preferred. From enquiries made abroad it was gathered that the use of artificial lighting for stimulating plant growth could not yet be said to have reached the stage of a commercial utility. On the other hand, the use of electrical bottom heat in frame culture is progressing rapidly and shows sufficiently promising results to justify extensive

trial in this country. A report, submitted to the Ministry of Agriculture, has been considered by the Rural Electrification Conference and at a special meeting held at the Ministry. In connection with the work in Germany reference should be made to the valuable assistance afforded by the Director, Professor Vormfelde, and the Staff of the Bonn Agricultural Engineering Institute, who not only supplied a large amount of literature on the subject, but provided every facility for visiting the vineyards in the neighbourhood.

(*d*) *Windmills for the Generation of Electricity.*—With a view to gaining information as to the progress made since 1925 preliminary tests were carried out during the winter on two windmill plants of different makes, representing the latest design adopted in this country. Although these both showed considerable improvement over the mills tested in 1925 as regards ease of handling and of control, quietness of running and safety, the outputs recorded were not greatly in advance of those obtained from the earlier machines. It was accordingly decided that no particular purpose would be served by publishing figures of performance ; enquiries can be dealt with as received and prospective users referred to the manufacturers.

III. Testing.

(*a*) *Ministry's Testing Scheme.*—During the year the following tests were completed :—L'Avenir Thresher, Manure Distributor (confidential test), Fuel Oil Carburettor, Wessex Milk Cooling Plant, Fern's Emulsifier, Alfa Laval Milking Machine, Hall's Milk Cooler (the four last-named in conjunction with the National Institute for Research in Dairying, Reading), Bamlett's Mower and Vickers' Agricultural Tractor.

(*b*) *Royal Agricultural Society of England.*—Following the procedure inaugurated in 1928, six implements entered as " New Implements " for the Society's Silver Medal at the Royal Show at Manchester were tested at the Institute or inspected by the staff and a report submitted on each. In the report of the Judges, special appreciation is expressed of " the carefully analysed and detailed report of the preliminary examination and tests."

(*c*) *Trials of Implements.—Combine Harvester-Thresher.*—As evidence of the interest awakened in the use of the Combine Harvester-Thresher by the Institute's Trials in 1928 and 1929 it may be mentioned that during the past harvest five privately owned combines were employed on English farms, with results in each case of a most promising nature. Trials were also held by the Ministry of Agriculture.

(*d*) *Experimental Machines.*—The sugar beet lifter referred to in last year's report as being constructed failed to fulfil the hopes entertained of it.

The combination tractor drill and hoe promises sufficiently well to justify the work being continued.

II.

LOCAL INVESTIGATIONS at ADVISORY CENTRES.

L.

CHEMISTRY.

J

46. ABERYSTWYTH : UNIVERSITY COLLEGE OF WALES.

The effect of repeated dressings of Nitrogenous manures upon the monthly yield and chemical composition of eighteen varieties of grasses cut as pasture.—This investigation has been in progress for three years, and the analytical work in connection with it is completed. It is hoped that the results will be shortly ready for publication.

The effect of maturity on the chemical composition of eleven varieties of grasses.—These results have been accepted for publication in the coming volume of the Welsh Journal of Agriculture. The investigation falls into two parts, (*a*) the changes in composition from the pasture to the hay stage ; (*b*) the changes in composition of the herbage during the autumn and winter months.

The nutritive value of edible weeds.—Samples have been taken from the lowland and upland pastures throughout the growing season, and it is proposed to continue this sampling during the winter and spring months. So far, some 70 samples have been examined. The results as far as they go promise to be of considerable interest and importance, for they show that several of these edible weeds are as rich, if not richer, in phosphoric acid and lime as many of the commoner grasses.

The distribution of protein and mineral constituents between the stem, leaf and panicle of the oat plant at various stages of growth.—Four varieties of oats were cut at the following stages of growth :—

(*a*) Panicle beginning to emerge.
(*b*) Panicle fully emerged.
(*c*) Milky stage.
(*d*) Under ripe stage.
(*e*) Fully ripe stage.

These results have been accepted for publication in the coming volume of the Welsh Journal of Agriculture.

The above paper is an introduction, and gives only part of the whole work that has been carried out at Aberystwyth on oats during the last six years.

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47. BANGOR : UNIVERSITY COLLEGE OF NORTH WALES.

The Soil Survey of Wales is now proceeding along routine lines. The classification of soils with series, adopted last year, is proving a satisfactory basis for the work. The Survey during the past season has been carried out principally in two areas, namely in Caernarvonshire and Flintshire. One point which emerges is the importance of drainage conditions in distinguishing soils. The

field work has been carried out by Messrs. D. O. Hughes, M.Sc., Brynmor Jones, M.Sc. (now of the Geological Survey of Nigeria), and W. G. D. Walters, B.Sc.

The general research work is still principally concerned with analytical methods. A grant from the Empire Marketing Board has permitted the appointment of Miss M. Richardson to work on mechanical analysis, with special reference to overseas soils. It has already been shown that the substitution of soda for ammonia, as a dispersive reagent, greatly facilitates dispersion and overcomes difficulties with certain refractory soils.

Mr. McLean has published a paper on the carbon-nitrogen ratio of a range of soils. He has also studied the action of hydrogen peroxide on soil organic matter. It appears that 3 per cent. peroxide may be a suitable reagent for a first practimation of soil organic matter. There are some indications that the proportion of the total organic matter thus attacked may be correlated with fertility. A note on the occurrence of elementary carbon (coal, etc.), in soils has been published.

Mr. Rice Williams has published an account of a method for determining exchangeable sodium in soils. The amounts present in North Wales soils are small. The rate of loss of lime from North Welsh soils is still being investigated.

The study of the composition of the clay fraction has proved of value in tracing the development of the soil profile in North Wales.

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48. BRISTOL UNIVERSITY.

Longleat Grazing Experiment.—This trial has been in progress since March, 1927, and affords a comparison between the extensive and intensive systems of grazing and manuring grass land. Records of yields (as cow-days per acre) as well as changes in the chemical and botanical composition of the herbage are being kept.

Development Commission Pasture Experiments.—Two centres in connection with this national scheme of experiments have been established and three-weekly samples of grass have been collected from each centre for analysis.

Nutritive Value of Pasture Grass.—A large number of samples of grass and hay are being examined chemically.

Iodine Content of Pasture Grass.—(In conjunction with the Rowett Research Institute.) Results obtained at Bristol show great variations in the iodine contents of the grass from field to field, and during different times of the season. A range of from 6·4 Y's iodine to 177·7 Y's iodine has been obtained at one centre.

Sugar Beet.—The investigations on the storage, analysis and lifting of sugar beet which had been conducted jointly by the

Universities of Oxford, Cambridge, and Bristol have been completed and fully described in the Journal of the Ministry of Agriculture (January, February and March, 1930).

The effect on the sugar content of sugar beet that were left untopped in the field for a few days before topping and carting to the factory was studied in the autumn of 1929. The data obtained pointed to the fact that this procedure resulted in a loss of dry matter, but no increase in sugar weight per acre.

The Eradication of Bracken.—Experiments of bracken control, which have been in progress since 1921, have now been completed, and a full report is in the course of publication. It has been found that bracken can be eradicated, or so reduced in height and density as not to interfere with grazing, by systematic cutting for two or three seasons. The time for cutting varies somewhat with localities, but it should be done when the fronds have reached their maximum growth. In the South-West of England this period is reached between June and July. Manuring or liming of bracken infested land is not a sufficient means of control.

Other Investigations in Progress.—Flax manuring, mixed corn crops for home consumption, sugar beet varieties, the effect of mole drainage on the physical characteristics of heavy soils, and the liming of arable land.

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49. CAMBRIDGE UNIVERSITY.

Sugar Beet.—(*a*) The plots laid down under the Ministry's 1929 scheme of demonstrations and investigations were sampled and weighed.

(*b*) Preliminary observations have been made on the occurrence of a mottled condition of the leaves of sugar beets in certain parts of the Province; the phenomenon appears to be associated with soil conditions and it is hoped to carry out a more extensive investigation next season in conjunction with members of the County Staffs in the Province.

Potatoes.—An investigation has been commenced to determine the influence of soil conditions, manuring and previous cropping on the occurrence of so-called "Potato Sickness," usually found in association with Eelworm. This investigation is being carried out in conjunction with the Agricultural Organisers for Bedfordshire and Cambridgeshire. Certain pot culture work has been carried out in Cambridge, and field plots have been laid down in the Gamlingay-Potton district.

Soils.—Experimental plots have been laid down on two types of poor fen soil to determine (1) the value of magnesium sulphate, (2) methods of improving the physical condition of such soils, (3) suitable crops.

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50. HARPER ADAMS AGRICULTURAL COLLEGE.

Experiments on the Cultivation of the Sugar Beet Crop in the West Midlands during 1928-1929.—The results of the third (final) year's experiments (similar in nature to those reported previously) are as follows :—

1. Increasing yield is obtained with decreasing distance between the rows.
2. No significant differences in yield are obtained on 4-in., 7-in. and 10-in. spacings of the plants in the row.
3. There is no apparent relation of weight of crop per acre and the area allocated to each plant.
4. Spacing has no apparent effect on Sugar Content.

Sugar Beet Clamping Experiment.—Results of the second year's work, which was extended to discover changes in storage in unwashed as well as washed and retopped beet, are as follows :—

1. The changes resulting in loss of sugar and dry matter took place the end of December in washed and retopped beet.
2. Similar changes in unwashed and un-retopped beet took place at an earlier date, i.e., end of November.

Failure of Crops at various pH Values.—Extending this work to crops other than sugar beet, the following tentative figures have been collected.

Potatoes pH 3·8. Oats pH 4·2. Kale and Rape pH 4·5. Swedes pH 4·9. Barley pH 5·3. Sugar Beet pH 5·3. Carrots pH 5·5. Red Clover pH 5·6. It is not intended to suggest that the possibility of calcium shortage or other allied factors plays no part in these failures.

Soil Survey.—The year's investigation of an area of 30,000 acres leads to the recognition of 51 series and 64 types. These include 38 main series and 13 local series.

Studies in Soil Formation and Profile changes in the Bridgnorth Series.—A preliminary study of this subject has been made. The second season's work is now in progress.

Liming Experiment on the Bridgnorth Series.—A Latin square (four-fold replication) of 0, 25, 50, 100 cwts. $CaCO_3$ per acre was laid down in 1928 on the Bridgnorth Series (mutual pH about 4·7). Results with barley in 1929 were as follows :—11, 17½, 18½ and 20 cwts. per acre.

The corresponding results for 1930 are not yet completed.

Grassland Experiments.—(*a*) *Small plots in connection with the Institute of Animal Nutrition.*—Analyses of the samples cut in 1929 show a very considerable increase in the calcium content of grass on the Bridgnorth Series (Bunter Sandstone) as a result of liming (5 tons chalk per acre).

(*b*) *Phosphatic dressings of Hayland on the Wenlock Shales* (in conjunction with Rothamsted).

Results of the first season show some advantage in favour of super-phosphate compared with Highland low-grade slag and mineral phosphates. (This experiment will be continued for 4 years.)

(*c*) *Small Plots.*—(Soil Survey) with different manurial treatments. There was exceptional response of grass on the peats to phosphates dressings (Super).

This work will be followed up.

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51. LEEDS UNIVERSITY.

Further results obtained in 1929 confirmed the fact that there is a close relation between the size of Sugar Beet and its sugar content, the smaller beet being richer than the larger. It is hoped to complete the investigation during the present season.

The effect of different forms of lime in combating finger and toe in swedes is being studied. Two sets of experiments on the Latin square principle have been laid down, but no results will be forthcoming until next season.

A study has been commenced of the probable causes of infertility of " Carr " soils. It appears that whilst acidity is an adverse factor, the unsuitable physical condition of the soil is quite as effective. An attempt is being made at one centre to improve the physical condition of the soil, by incorporating with it large quantities of clay material.

An investigation into the soil conditions most suitable for the growth of Peas (picked Green) has been conducted in co-operation with the Agricultural Economics Section.

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52. MANCHESTER UNIVERSITY.

The chemical examination of soil samples from the experimental plots laid down by the former Adviser in Chemistry—Dr. A. M. Smith—to determine the effect of liming on the control of potato " sickness," was continued at the beginning of the year. The results confirmed the previously formed opinion that liming effects no control over the disease or over the degree of infestation by the potato eelworm—*Heterodera schachtii.*

An examination was made of soil samples taken from grassland experiments set out within recent years by the Lancashire Agricultural staff. It was found possible to classify the soils into groups according to their acidity and phosphoric acid content, and this grouping corresponded fairly closely to field observations of the response to dressings of lime and phosphates applied separately or in combination.

A considerable amount of laboratory work has been carried out on methods of chemical analysis of soils, concerning particularly the soil phosphoric acid. The action of various dilute acid solutions on the soil has been examined, together with the adsorption of phosphoric acid from solution in presence of various acids. The experimental work on this point is still in progress and it is hoped to obtain eventually some evidence regarding the chemical composition of the soil phosphates.

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53. MIDLAND AGRICULTURAL COLLEGE.

Day to day Variation in the Composition of Milk.—Two years' records of the composition of the milk of the College herd, obtained from daily supplies of the milk, were completed in March, 1930. The data is being examined and a paper prepared.

Molasses Beet Pulp Enquiry.—The investigation into the conditions responsible for the appearance of a fishy taint in milk during the feeding of molasses beet pulp, has been continued during the past year. This work is now under control of a Committee appointed by the Ministry of Agriculture, and the investigation is being carried out conjointly with Harper Adams College and the National Institute for Research in Dairying, Reading.

There is some evidence to indicate that composition of pulp, quantity fed at one meal, and time interval between feeding and milking, are important factors. Investigation into these points is being continued during the winter of 1930-31.

Soya Bean Variety Trials.—In spite of a favourable season in 1929, the results from the four varieties were very disappointing. The heaviest cropper produced seed at the rate of 6 cwts. per acre, a yield much below that which has been obtained in southern counties. The two most promising varieties were sown this year (1930) but the dull, rather wet season has resulted in an almost complete failure. The yield of seed is so small that it has been decided to discontinue the trials. It is quite apparent that the Midland counties are too far north for the successful cultivation of this crop.

"Soil Deficiency" Diseases.—Numerous cases occur every spring of partial failure of crops—particularly cereals—in which no plant pest or obviously bad soil condition is responsible. Samples of the young plants from good and bad patches in the same field were taken last spring on four farms, and analyses made of the mineral constituents in particular. It is hoped to continue this work next season.

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54. NEWCASTLE : ARMSTRONG COLLEGE.

The study of soil fertility problems has again constituted a large part of the work, but advice has been sought by farmers on a great variety of subjects. The investigation of several interesting stock poisoning cases has been successfully undertaken in conjunction with Mr. W. Lyle Stewart, M.R.C.V.S. The Department has, during the past three years, accumulated valuable experience in veterinary toxicology, and requests for assistance in cases of stock poisoning are increasing.

Mr. J. Hargrave, B.Sc. (Demonstrator) co-operated with the Adviser in a study of the composition of kitchen refuse produced by hotels and restaurants in Newcastle-on-Tyne. This work was undertaken at the request of the Northumberland and Durham Agricultural Valuers' Association, who made a grant towards the cost of the investigation. Weekly samples from any one source showed considerable variation. The dry matter of refuse generally proved to be of remarkably high feeding value, but there appears to be no relation between the quality of the material and the class of eating house producing it. The oil content of the dry matter was usually high, and in one instance reached 45 per cent. Residual values calculated by the Advisor and his collaborator have been adopted by the Association. A paper embodying some of the results obtained has been accepted for publication and will shortly appear.

Investigations into the yield and quality of grass on the Tree Field pasture plots have been undertaken with the assistance of Mr. F. J. Elliott, B.Sc., A.I.C. (Durham County Senior Research Scholar). Fortnightly cuttings were made during the growing season of 1930 on randomised and duplicated areas of certain plots. It is not anticipated that the results of this work will be available for some months.

Other work which is in progress or has recently been completed, includes an attempt to evolve a standard technique for the estimation of pH in soil suspensions by means of the quinhydrone electrode, and nitrification studies of soils from Cockle Park and Houghall. The former investigation is on somewhat similar lines to that which is being carried out by members of the Soil Reaction Measurements Committee of the I.S.S.S.

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55. OXFORD UNIVERSITY.

The data collected from the Regional Soil survey of Northamptonshire have been collated, but it has meantime been found impossible to meet the cost of publication. The work is being augmented from time to time, and the data already available are proving very valuable in connection with advisory work. A research student is carrying out, under the supervision of the advisory chemist, an intensive survey of the Market Harborough area. The results of previous

investigations into the cultivation and storage of sugar beet were published in the form of a joint paper. Some further work was carried out with this crop in conjunction with the Northampton Farm Institute. Other subjects under investigation have been the composition of the herbage from store and fattening pastures on certain geological formations, and the composition of swedes as affected by manuring.

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56. READING UNIVERSITY.

Manuring of Malting Barley.—A trial was made in quadruplicate of equivalent amounts of two complete mixed manures of which one contained its nitrogen and potash in the chloride form, while the other contained them in the sulphate form. The yields of grain are just to hand, and show no significant difference between the two forms.

Duration of Herd Life of Dairy Cows.—Particulars of some 1,500 cases of removal of cows from herds, including the causes, age, yields, etc., were collected through three milk recording societies. The scheme has now been extended to other societies, and the work is proceeding.

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57. SEALE HAYNE AGRICULTURAL COLLEGE.

The main problems in this province are concerned with crop production, and arise from an increasing need for improvement in both yield and quality of a large variety of crops. A high level of soil fertility is required to be maintained in the districts devoted to intensive cultivation of fruit, flowers and vegetables on the one hand and a better utilisation of the land used for a highly developed dairy and stock rearing industry on the other. The enormous variation in the soil types and the special peculiarities of the soils in Cornwall especially has necessitated the development of full and detailed methods of investigation for these problems.

More or less permanent toxic effects are produced by the injudicious use of lime, sea sand or mineral phosphate fertilizers. The increasing number of cases of this sort which have been reported from many parts of the two counties suggest that the question is one of considerable practical and economic importance. Full use is being made of the facilities thus offered for studying the cause of these phenomena, and investigating the limits to the use of such materials, the optimum balance of applied fertilizers, methods of amelioration, and susceptibility of different crops. In this connection the fullest use is being made of pot culture experiments.

For this purpose also the detailed replicated liming trial started four years ago near Carn Brea in Cornwall is regarded as of con-

siderable importance, and also the treatment of the soil at the Devon County Council horticultural experimental plots in the Tamar Valley in the control of Patch Disease of Strawberries.

With a view to improving the technique of studying these and similar problems considerable time and work has been devoted to the development of new, more accurate and quicker methods of analysis, such as the determination of sodium, nitrates, ammonia, exchangeable potash and available phosphates.

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58. SOUTH EASTERN AGRICULTURAL COLLEGE.

The work of the Chemistry Research Department has continued to be connected mainly with spray materials and spraying. Opportunities have been taken to examine any new spray materials which have appeared, and to obtain information concerning their value.

In collaboration with the Mycological Department, biological tests have been made with the object of studying the action of sulphur in direct contact with the fungus. Also upon the fungicidal action of various solutions containing polysulphide sulphur. A preliminary investigation of the fungicidal action of vegetable oils has been a further subject of collaboration.

The defoliation caused by sulphur sprays in the case of certain varieties of gooseberries has been examined.

Orchard spraying trials at two centres—against apple scab—have been continued. Dusting with " dry Bordeaux mixture " as a substitute for spraying with the ordinary Bordeaux mixture has been the subject of a small trial.

The Fruit Soils Survey which is being made in collaboration with the East Malling Research Station has been continued. The total area already surveyed covers about 50,000 acres. In the course of the survey some 40 soil series have been established, but many of these are local in character and limited in extent. About a dozen of the series are being studied in detail.

M.

ENTOMOLOGY.

59. ABERYSTWYTH : UNIVERSITY COLLEGE OF WALES.

Control of Pea and Bean Weevil.—A number of experiments were carried out against these pests, which, in some years, cause considerable damage in the province. Several deterrent chemicals were used, and it was found that a Chlorcresylic Acid dust gave the most satisfactory results, 90 per cent. control being obtained. An important point is that covering the young plants with soil, as is often recommended, always resulted in the rotting of the plants irrespective of the type of soil on which the experiment was carried out.

Control of Millepedes.—Hitherto no satisfactory method of killing these pests was known, and as a severe outbreak occurred in a large garden the opportunity was taken of laying down control experiments. Several chemicals were tried, and it was found that a solution of Calcium Cyanide in water, well watered in, gave almost a complete kill. Naphthalene was found to be merely a repellent, and that the millepedes return as soon as it becomes dissipated in the soil.

Orchard Pests.—The value of Pyrethrum extracts in controlling fruit tree aphides was tested, with valuable results.

Acarine Disease Control.—Frew's method of controlling this disease was tested at several centres. Subsequent examination of representative samples from the treated stocks showed that the method gives a very high degree of control.

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60. BANGOR : UNIVERSITY COLLEGE OF NORTH WALES.

Investigational work has again played a large part in the adviser's duties, as this year has terminated several of the minor investigations carried out during the first three years of office, when a general survey of the problems of the province was being made.

Fundamental research on *Lucilia sericata* (Sheep Maggot Fly) has been continued and records made of certain ecological facts. Experiments with various larvicides have been extended, and a survey and study of factors influencing infestations in the field have been initiated.

In conjunction with the County Agricultural Organisers, Anti-Warble Fly Campaigns have been instigated in the province. In addition, critical trials on the toxicity of Derris Powder obtained from various sources have been conducted. Three sources provided powder of high toxicity when applied as a wash for the destruction of warble fly larvae. One source yielded a powder of little value,

and this has since been withdrawn from the market. Two proprietary washes failed to give satisfaction. A technique for arriving at reliable results in this work was evolved.

The adviser has continued his studies on the Collembola. Among other investigations the effect of variation in relative humidity on the duration of the incubation period of *Sminthurus viridis* has been ascertained.

The Survey of Aphid Infestation at Special Seed Potato Centres commenced in 1928 has been continued. The general infestation of potatoes with aphides was high this season. The curve of intensity of infestation in the field has been studied of both *Macrosiphum gei* and *Myzus persicae*. The condition of these aphides at the different centres with respect to Virus Diseases has been investigated.

Field studies on the infestation with Swede Midge (*Contarinia pasturtii*) in relation to Varietal and Manurial Trials of Swedes have been completed, and the results will shortly be published.

Similarly, the trials on the control of certain Horticultural Pests have been completed. These have involved the use of Corrosive Sublimate Solution for Cabbage Root Maggot and Whizzed Naphthalene for the same pest and also for the Carrot Fly. In addition, the use of cut grass lawn mowings for the control of Carrot Fly has been demonstrated.

A special investigation on the Status of the Raven in North Wales was carried out at the request of the Ministry. It was shown that in the area from which complaints had been received, only six pairs of Ravens nested within a five mile radius. Confusion was prevalent owing to the synonomy of Welsh names for the Corvidae, but in no instance was it claimed that the Raven was responsible for attack on living and active sheep. The increase in number of Carrion Crows and Rooks had, no doubt, led to the belief that the Ravens had increased, and it was evident that the Carrion Crow was responsible for most of the losses attributed to the Raven.

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61. BRISTOL UNIVERSITY.

Egg Killing Winter Washes.—The work on egg-killing washes is being continued in collaboration with the Research Entomologist and the Biochemist. Further extensive field trials have been carried out with the high boiling neutral tar-distillate wash, especially with regard to the control of Capsid Bugs on apples. The results obtained were less consistent than in previous years and indicate the existence of complicating factors which require further investigation. A new wash embodying "high neutral" oils and heavy (medicinal) paraffin has given striking results against Capsid Bugs on black currants and results obtained on apples suggest that this wash may also prove to be of high value for that branch of the

Capsid Bug problem. Promising results have also been obtained by the use of this wash against the eggs of the Red Spider.

Pear Midge.—Further experiments are contemplated, employing new methods, against the Pear Midge. Weather conditions were responsible for the absence of results during the year

Apple Sawfly.—A series of trials was carried out against the Apple Sawfly, using nicotine-soap and Pyrethrum washes. The results were inconclusive and further experiments are necessary. The exact time of application of the sprays under the conditions obtaining in this province, require determination.

Cleansing of Nursery Stock.—Preliminary results of a useful character have been obtained on the cleansing of nursery stock (apples) from Woolly Aphis.

Beet Carrion Beetle.—Satisfactory control of the Beet Carrion Beetle has been effected by the use of Lead Arsenate dust.

Naphthalene Treatment.—Work on naphthalene against carrot fly and potato sickness has been continued.

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62. CAMBRIDGE UNIVERSITY.

The Control of Apple Capsid Bugs (*Plesiocoris rugicollis*) *by winter spraying.*—Experiments were carried out in Cambridgeshire, the Isle of Ely and Hunts, to test the value of Long Ashton Washes, Modified Long Ashton Washes, Mineral Oil Emulsions, and mixtures of the above. The mixtures gave the best controls, but caused damage to the undercrops such as gooseberries.

The Control of Capsid Bug (*Plesiocoris rugicollis*).—Comparison was made of Pyrethrum washes as compared with ordinary Nicotine spraying. One of the Pyrethrum washes gave results very similar to those of Nicotine, and another gave less favourable results.

The Control of the Common Green Capsid Bug (*Lygus pabulinus*).—These experiments were carried out in Cambridgeshire and showed that Long Ashton Wash was of very little value in reducing this pest. One proprietary Mineral Oil Emulsion gave a very good commercial control. Another proprietary Mineral Oil Emulsion gave less favourable results.

The Control of Red Spider.—These experiments were carried out in two orchards in Cambridgeshire, one in Essex and one in Norfolk. The results were very variable, but in Essex one of the Proprietary Mineral Oil Emulsions applied in the winter gave a good control. In Cambridgeshire a Mineral Oil Emulsion and Lime Sulphur both gave good results when applied in the spring. Heavy sulphur dusting also gave a good control.

The Control of Apple Sawfly.—These experiments were designed to decide the best time of application and also to test out Pyrethrum and Mineral Oil Emulsions.

Soft Soap and Nicotine gave the best results, which were very good indeed, and the best time of application was confirmed as being seven days after petal fall.

The Control of Apple Case Bearer.—No results were obtained from these experiments.

The Control of Apple Scab.—This experiment was carried out in conjunction with Mr. Kent in the Isle of Ely. Its object is to find out how long it takes for badly scabbed trees to recover.

Wet versus Dry Spraying.—Routine spraying experiments have been continued in the Isle of Ely and Hunts. to find out if wet spraying can be replaced by dry spraying.

The Control of Carrot Fly.—Large scale trials have been carried out at two centres.

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63. CARDIFF : UNIVERSITY COLLEGE OF SOUTH WALES.

Further trials for the control of Cabbage Root Fly, Onion Fly and Carrot Fly.—The use of Naphthalene as a deterrent has given very satisfactory results during 1930. The quantity used previously for Carrot and Onion Flies was reduced to 1 oz. per sq. yd. without affecting the results, and the naphthalene used was a more crude form than the Grade 16 used previously. It proved equally successful and was considerably cheaper.

Control of Potato Eelworm.—Tests of crude naphthalene have resulted in partial control being obtained at four centres.

Warble Fly Control.—Demonstrations on an extensive scale were carried out. Derris-soft soap wash was used as a larvicide and three dressings at intervals of one month, commencing late March, were found to give almost complete control.

Greenhouse White Fly.—Supplies of the parasite *Encarsia formosa* were obtained from Cheshunt, and from the centres where these became established further parasite distributions were made. These introductions have proved very successful, especially when made before the end of May.

Spraying Trials and Demonstrations.—A number of winter spraying trials and demonstrations were undertaken, using various Tar Distillate washes. The control of Red Spider, in addition to other pests, was attempted by using a combined Tar Distillate spray with a sulphur preparation, with a fair measure of success. Oil emulsion washes were also tried successfully.

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64. HARPER ADAMS AGRICULTURAL COLLEGE.

Beet Pigmy Beetle (*Atomaria linearis*).—Investigations on the life history, bionomics and control were continued. Studies into the life history and bionomics are incomplete, but consistent highly satisfactory control has been obtained in the case of sugar beet by steeping the seed prior to sowing in a solution of phenol and magnesium sulphate.

Springtail (*Bourletiella hortensis*) *Control.*—Three lines of control were attempted: (a) chemical treatment of the seed, (*b*) soil treatment by insecticides prior to and after sowing the seed, and (*c*) cultural methods. Of these lines of control, the latter gave the most encouraging results.

Beet Carrion Beetle (*Silpha sp.*) *Control.*—The use of lead arsenate either as dry or wet spray proved extremely satisfactory under field conditions.

Onion and Carrot Flies Control.—A comprehensive study of the control of these pests by means of Crude Naphthalene Compounds was conducted. It is found that at least five applications are necessary for a commercial control.

Apple Capsid and Red Spider Control.—Combined sprays of tar distillates and mineral oil washes gave very successful results against over-wintering eggs of these pests.

Apple Capsid and Winter Moth Control.—Field experiments were carried out on apples (five centres) in Shropshire and Staffordshire. The sprays used were (i) Long Ashton Two Solution Wash, (ii) Long Ashton Modified Wash, (iii) Mineral oil emulsion spray, (iv) Combination of 1 and 3, and (v) proprietary "Standard" spray.

Wireworm Control.—A comparative study of the effect of certain soil insecticides and seed dressings as means of controlling this pest in arable crops was carried out.

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65. LEEDS UNIVERSITY.

Mangel Fly.—A study of the feeding habits of the first brood of flies shows that they are largely restricted at this time of year to the flowers of common umbelliferous plants, and much good can probably be done by destroying the flowers before they open.

Black Aphis.—The development of the Aphis was checked by lady-birds and other predacious insects, and it was not until autumn that the aphids began to appear in any number. They were found chiefly on Dock plants, and to a small amount on French beans.

Turnip Flea-beetle.—The emergence of the new brood in August and September showed that a black non-striped form, viz., *Phyllotreta atra* is implicated in the attack on the Wolds. On the other hand, *Ph. undulata* is not so prevalent as in some other districts.

Potato Eelworm.—Field experiments were made as last year. In addition to chemical dressings, of various kinds, the mustard was sown in plots to be planted with potatoes in 1931.

Stem Eelworm.—An attack on field grown Broad Beans was noticed for the first time, and is being investigated.

Warble Fly.—In conjunction with the agricultural staff, an experiment was made to test the efficacy of dressings in killing the larvae inside the warbles.

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66. MANCHESTER UNIVERSITY.

Studies on the Biology of Sawflies Infesting Gooseberry.—Three species of sawflies are found infesting gooseberry and red currant in Britain: *Pteronus ribesii, Pteronus leucotrochus* and *Pristiphora pallipes.* Parthenogenesis occurs in the three species. In *Pteronus spp.* virgin females produce males only, while in *P. pallipes* virgin females produce females only. Considerable differences occur in the annual cycle of generations. *Pteronus ribesii* has three generations per annum under the conditions prevailing in the North-West, whereas *P. leucotrochus* has only one generation a year. *P. pallipes* has four generations a year. In *P. ribesii* development seems to be retarded in some specimens so that only one or two generations are completed during the year. This phenomenon tends to maintain a balance between the sexes, which otherwise seem to show a tendency towards alternation in sex predominance.

The Apple Tree Red Spider.—Investigations have shown that under the conditions prevailing in the North of England, the apple tree red spider hatches from overwintered eggs towards the end of May. The young mites make their way to the leaves, where feeding and reproduction take place. The rate of increase in numbers during the early summer appears to be about 4 to 1, with the period of greatest intensity occurring about July. Where spraying reduces the hatching of red spiders, the initial infestation in the spring is low, but the subsequent rate of increase may be as high as 15 to 1. In experiments on control, white oil emulsions and white oil and tar distillate in combination have been found valuable in reducing the initial infestation, and efficient control during the summer has followed the use of lime sulphur sprays at the pre-blossom and post-blossom periods.

Investigations on Insect Pests of Cereal Crops.—The study of the frit fly in the North-West has been continued, and it has been observed that some fluctuation may occur in the amount of injury which follows successive generations of the flies during the annual cycle. In 1930 the spring swarm of flies emerged irregularly and tiller injury was scarcely apparent. The summer swarm was very numerous, and heavy infestation of the panicle in the sheath and

late tillers followed. The emergence of the third brood of flies was so late, however, that grain injury was only about half as severe as that observed in 1929.

Preliminary observations on the occurrence and distribution of gout fly of barley revealed a remarkable absence of parasites, and it is thought that this may account for the severe local injury caused by the insect. A study of the biology of the gout fly in the North-West, and the extent of damage caused by its attacks, is in progress.

Investigations on "Potato Sickness.—Further observations have substantiated the work reported last year and published in the *Journal of Helminthology* (VIII, 1930).

The yearly fluctuations in yield and pathological condition of the potato plants appear to bear little relation to the cyst content of the soil. A study of the cyst content of land under rotation cropping reveals a rapid initial decrease in the number of cysts present, but the rate of decrease gradually slows down in the course of two or three years.

Experiments on soil treatments for potato sick areas continues to demonstrate the value of calcium cyanamide for the peaty soils of the southern portion of the North-West Province. The application of a dressing of 3 cwt. per acre of calcium cyanamide was followed by a yield of over 8 tons of potatoes per acre, while on untreated check plots a yield of only 4½ tons per acre was obtained.

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67. MIDLAND AGRICULTURAL COLLEGE.

The Rook is being studied as an example of a bird of great economic importance to Agriculture. Its numbers and distribution in the five midland counties are now known. The problems of quantity and quality of the food consumed, the competition with other species, the fluctuations in numbers through breeding, migration, etc., are being studied.

Soil insects, or those species whose larvae spend most of their lives in the soil as pests, are being studied, especially with a view to their control. Attempts are being made to control Chafer attacks on grassland and wireworms, cutworms, slugs, etc., on arable land.

The effect of weather upon insects, especially rainfall, is under study.

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68. NEWCASTLE : ARMSTRONG COLLEGE.

An interesting attack of *Wireworm* was investigated in Co. Durham, where 1 acre of a 5 acre field of oats was destroyed. An examination of the field showed that the pest most probably had been introduced by old pit-pony manure overgrown with rough grass, as it was only when this had been applied that the damage was observed. Further, with regard to *Wireworm*, it may be noted

that in May certain fields of oats affected by night frosts began to show additional damage from wireworms. In Co. Durham, for example, in a field which showed much browning of the leaves by frost, about 75 per cent. of the crop showed this further damage by wireworms. It was recommended to harrow in nitrate of soda, good results from which treatment were reported later in the season by the farmer.

Mangold Fly caused much damage to a field of beet in Northumberland where the plants were affected to the extent of 80 per cent. In connection with this attack, trials were carried out with a nicotine spray. This had some effect upon young larvae, some of which were found later to be dead or moribund in the leaves through the nicotine treatment, but older larvae were unaffected.

In the beginning of the year the Adviser devoted much time to the study of his own records relating to the Diamond Back Moth and its parasites, as well as of reports which were available as relating to other parts of the country. The latter were obtained chiefly from the Monthly Summaries compiled by the Ministry of Agriculture from the Monthly reports of Advisers. The aim of the study was to try to correlate the fluctuation of the Diamond Back Moth population with the weather conditions and parasites over the years 1914-1929, in addition to recording the behaviour of the insect during these years. These are being published in the Journal of the Royal Horticultural Society. Observations in the north were continued in July-September, 1930, but moths were very few, and larvae were practically absent from swede fields.

Trials with Naphthalene and Sulphate of Potash were carried out in an allotment against the *Eelworm, Heterodera schachtii* associated with failure of the potato crop, but no definite or satisfactory results can be recorded.

A useful test with tetrachlorethane as a fumigant against *White Fly* was carried out in two glasshouses in Co. Durham, and was successful in getting rid of the pest. The houses contained 28 varieties of plants, and were kept at a temperature of 62° F., and the plants were watered some time before introducing the fumigant. A list was obtained of 23 varieties of plants which showed no ill effects from the treatment; of the remaining five, Chrysanthemums suffered badly, *Houchera sanguinea* was badly affected but recovered, while of three Coleus plants, only one showed injury. *Asparagus plumosa* and Canna were slightly affected.

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69. OXFORD UNIVERSITY.

Work on the breeding of oat varieties resistant to attack by the frit fly has been continued with the assistance of a grant from the Advisory Committee on Agricultural Science. Resistant varieties found in Sweden and Denmark have been crossed with a number

of standard English sorts and others possessing good seed or straw qualities. The hybrid plants were so grown as to produce maximum progenies. The seeds of F_2 plants have been set out during April so that the resulting plants might be at the most susceptible stage during the period of maximum fly prevalence. Plants with infested primary shoots, constituting about two-thirds of the whole, have been discarded. Plants of the F_3 generation with unattacked primary shoots have been harvested, and their seed collected separately. Seeds of F_3 plants showing promise of quality when compared with the standard variety Victory have been retained. Seeds of F_3 plants have been again set out individually in order to eliminate lines accidentally missed by the fly and also lines resistant to fly but otherwise unsatisfactory. This selection has left 64 lines existing at the end of the past season. There appear to be at least 40 per cent. more resistant to fly attack than Victory. The majority shoot a few days earlier than Victory, and they carry a considerably greater number of panicles (up to 70 per cent. more). A number of these will probably be eliminated on grounds of quality and general character of the straw.

Certain other cross-bred material shows considerably greater power of recovery than the standard Victory. The work is being continued.

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70. READING UNIVERSITY.

The Strawberry Blossom Weevil (*Anthonomous rubi*).—The life history of this weevil has been worked out, including its hibernation habits, oviposition and approximate duration of the larval and pupal stages in the field. There is only one generation per year. Strawberries and raspberries are the only plants of economic importance known to be attacked. Preliminary attempts at control have been commenced. Trapping of the adults by suitable devices will probably form the basis of this work.

The Crane Flies (*Tipulidae*) *of Economic Importance.*—Crane Fly larvae were collected during the summer from many places and the flies bred out. Eggs obtained from known pairs of flies have been hatched and the larvae are being carried on through all their stages. The main object of this investigation is to provide a key by which the larvae can be identified when found in the field, although certain details of the life histories of the species concerned will receive attention.

Investigations on Winter Moth Caterpillar Infestations.—Mr. P. A. Bottomley, working for his Diploma in Horticulture with Distinction (Entomology) co-operated in this work and incorporated the data obtained in his Thesis. Information on the time of maximum emergence of the moths, the relative importance of various species, the infestation of trees by small caterpillars carried by the wind,

and the power of various types of tar oil washes to kill the eggs of the Winter Moth was obtained. Work on the same lines is still proceeding in order to obtain further data on these points.

An Outbreak of Pigmy Mangold Beetle (*Atomaria linearis*) *on Sugar Beet.*—Very severe attacks in Hants and Dorset were investigated during June, and an examination made of the conditions governing the attacks. It would appear that successive cropping of the same field with sugar beet is likely to cause this damage to become increasingly severe, and the preliminary investigations on this point will be followed up.

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71. SEALE HAYNE AGRICULTURAL COLLEGE.

Pests of Narcissus.—Problems relating to bulb culture rank of primary importance in the Province. A poison bait spray has been devised which shows promise against the adult stages of the bulb flies, *Merodon equestris* and *Eumerus tuberculatus*, and the detailed biology of the former fly is being further investigated. Further work on the normal biology of the stem and bulb eelworm, *Tylenchus dipsaci*, is in progress. The grant of additional financial assistance is very materially assisting the foregoing investigations.

Pyrethrum.—Work on pyrethrum growing continues. A set back was experienced as regards the field scale plot owing to depredations by rabbits. The ground has been fenced and the experiment will be continued next year. The smaller plot experiments are still in progress. Some seed has been saved and will be subjected to periodic germination tests. Flower heads have again been harvested with a view to testing the toxicity, which in previous years has been high.

The Vine Weevil, Otiorrhynchus sulcatus.—An investigation of the life-history and a review of the possible methods of controlling this severe glasshouse pest continues. It has been established that the adult weevils survive the winter and oviposit freely during their second season. Baiting and collecting adults has completely eradicated the pest from one large nursery in Exeter.

A Parasite, Aphelinus mali, of the woolly aphis.—This parasite is now firmly established in North Devon. No releases have been made in the area since 1926, but the aphis is now very much reduced in the original four acre orchard. The parasite is abundant, has withstood four consecutive winters, and has spread to another orchard 500 yards away.

Strawberry Mite, Tarsonemus fragariae.—The discovery that this mite, recently described from Kent by Massee, is abundant in the province has led to the commencement of a full investigation of the

significance of the mite. Control experiments are in progress and already give promise.

The Cabbage Whitefly, Aleurodes brassicae.—The study of this pest continues.

72. SOUTH EASTERN AGRICULTURAL COLLEGE.

Capsid Bug Investigation.—The life-history of both the Apple Capsid (*Plesiocoris rugicollis* Fall.) and the Common Green Capsid (*Lygus pabulinus* Linn.) have again been studied, and, apart from some difference in the commencement of the hatching period and the period of the development of the subsequent Instars, they have shown no appreciable difference from the previously known life-history.

The Common Green Capsid has been found causing injury to the developing fruitlets of red currants; this is an apparently new record.

The Apple Capsid has been found to be capable of passing through its whole life-cycle upon currants.

Oviposition of *pabulinus* has been critically studied. The migration of this capsid to and from herbaceous plants has been subjected to research, with a view to obtaining information with reference to the most suitable period for the initiation of control measures in the spring; this has been found to be during the early part of May.

The control of both capsids has been experimented with, and it has been established that within this Province the use of ovicides does not give commercial control in many instances, and that more reliance may safely be given to spring control measures. In this connection, the early initiation of spring control measures is rendered imperative in view of the fact. that the earlier stages of these capsids are more susceptible to treatment than are the later ones.

73. ABERDEEN : NORTH OF SCOTLAND COLLEGE OF AGRICULTURE.

Bee Disease.—Advisory work in connection with bee diseases has been continued steadily during the current year. During the past 12 months over 250 letters were received from 178 bee-keepers, of whom 154 sent 352 samples, consisting of over 5,611 individual bees for examination and report. Amongst the samples 167 had Acarine Infection, 17 Nosema Disease, 3 Amoebic Disease, 7 Bee Paralysis, 3 Brood Diseases and 4 cause of disease uncertain. The course of Amoebic Disease in a colony of bees is being studied. Acarine Infection has been reported from 11 counties in Scotland, 17 in England, 2 in Wales and 2 in North Ireland. Frow's mixture (2 parts nitrobenzene, 2 parts petrol, 1 part safrole) is often recommended by the Department for the treatment of Acarine Infection.

74. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

The Advisory Entomology Department was constituted on 1st July, 1930. At the moment, the existence of the new department does not seem to be well known to farmers, and they are slow to make use of it. It is hoped, however, that this will gradually improve and every effort will be made to get in touch with those requiring advice.

During the three months from July to September, the work has been chiefly of a preparatory nature, getting together the necessary material and books.

A few enquiries have come to hand and have been reported on, including an outbreak of gout fly on barley at Stirling, and an attack by a small weevil. *centhorrynchus contractus*, on turnip in the Orkney Islands. The latter insect appears to be more common in the North, and was reported on many years ago by Miss Ormerod.

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MYCOLOGY
and
BOTANY.

75. ABERYSTWYTH : UNIVERSITY COLLEGE OF WALES.

Covered Smut in Barley.—Experiments were carried out at the Welsh Plant Breeding Station to test the efficacy of various methods of seed treatment. Semesan gave the best results with ·04 per cent. smutted ears, followed closely by copper sulphate with ·06 per cent. smutted ears. Formalin 1 : 480 and copper carbonate gave 2·52 per cent. and 2·15 per cent. diseased heads respectively. An addition of lime to copper sulphate which is commonly practised by farmers to accelerate drying the grain decreased the efficacy of the treatment.

Control of Grey Speck Disease of Oats.—An application of manganese sulphate at the rate of 3 cwts. per acre at seeding time gave complete control of the disease. From data obtained at harvest time an increased yield of approximately 42 per cent. was recorded in favour of treated plots.

Onion Mildew.—Experiments on the Control of Onion Mildew were continued in the College Experimental Garden. Owing to the scarcity of the disease no definite conclusions were arrived at. It was, however, observed that colloidal sulphur at the strength 1 : 80 scorched the foliage rather considerably as compared with Bordeaux treated plots.

Dry Rot of Swedes.—Trials were conducted, in co-operation with the Advisory Mycologist for Reading province, at two centres, but owing to the ravages of the Turnip Flea Beetle no conclusive results were obtained.

American Gooseberry Mildew.—The testing of wet and dry methods of control was again undertaken during the past year. Lime sulphur gave good control in slightly infected gardens, and special dusting sulphur also gave good results.

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76. BANGOR : UNIVERSITY COLLEGE OF NORTH WALES.

Virus diseases of potatoes forms the main line of work. Farm trials have shown (*a*) that very different reactions to leaf-roll and mosaic infection occur in seven varieties tested. In all, mosaic had little effect, but leaf-roll almost exterminated some varieties, e.g., Arran Crest and Herald, was extremely severe in others, and produced relatively little loss in one, i.e., Field Marshal. In the last variety, however, the plants exposed to leaf-roll were very severely affected by "crinkle;" (b) that seed produced on certain Welsh farms yields as heavily as stock seed from Scotland; (c) similarly trials have demonstrated the vast improvement effected in the health of certain stocks of the variety Golden Wonder in Scotland, and this variety has been compared with King Edward. It was

shown that the yield of the former in weight of tubers is less than the latter, but, owing to the very high dry-matter content, the weight of dry-matter per acre was more than with King Edward. Glass-house experiments have shown that *Myzus circumflexus* is almost as efficient a transmitter of leaf-roll as is *Myzus persicae*, but since it is only occasionally recorded out of doors, it is unlikely to be of importance in causing degeneration of stocks. Pot experiments are in progress to clear up the uncertainty as to whether soil fauna may be concerned in spreading virus disease.

Field trials have again demonstrated that the incidence of blight is not related to the age of the potato plants. Common soda has given promising results in garden trials for the control of Finger and Toe in Brassicas.

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77. BRISTOL UNIVERSITY.

During the year work on diseases of fruit was continued, while special attention was again paid to diseases of market garden crops. The latter project was much advanced by the appointment of Mr. B. O. Mulligan for special work on the subject. Following are some of the most important pieces of investigational work.

Apple and Pear Fruit Rot.—This disease was found to be prevalent and widespread throughout the whole Province in the autumn of 1929 and again in 1930. It develops only on fruits which have touched the ground, and develops rapidly in storage, where it may spread from fruit to fruit. The causative organism is *Phytophthora Syringae*, hitherto recorded only from Ireland.

Die-back of Apples.—Considerable attention was paid to a die-back of apple tress which occurred in many parts of the Province in the spring of 1930. The die-back was associated in every case with a *Cytospora*.

Septoria on Strawberries.—*Septoria Fragariae* was found to be associated with a destructive blossom blight and fruit spot, especially in the variety "Sir Joseph Paxton."

Diseases of Dwarf Beans and Peas.—Trials of resistance to foot rot (caused by *Fusarium martii var. Phaseoli*) were carried out, while a bacterial blight was found to be prevalent in the Evesham area. Detailed work was also carried out on a *Fusarium* foot rot of peas.

Vegetable Marrow Mildew.—Excellent control of vegetable marrow mildew was got from the use of sulphur dusts.

Willow Rusts.—The biology of the rusts of basket willows was worked out, the rust on *Salix triandar* being identified as *Melampsora Amygdalinae* and that on *Salix viminalis* as *Melampsora Larici epitea*.

The following diseases were also made the subject of special investigation :—Die-back of black currants, cherry leaf spot, raspberry die-back, asparagus diseases, lettuce diseases, "chocolate spot" of broad beans, mint rust, "white tip" of leeks, potato sickness, vegetable marrow mosaic, *Fusarium* disease of early flowering gladioli, *Fusarium* wilt of carnations and nettlehead of hops, while large numbers of field control trials were carried out.

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78. CAMBRIDGE UNIVERSITY.

The following is a brief summary of the subjects on which the Mycologist has worked during the current advisory year :—

(1) The effect of *Tilletia caries* on the development of the wheat ear.
(2) The action of iodine as a fungicide for *T. caries*.
(3) Biologic strains of *T. caries*.
(4) Action of ultra-violet on certain fungi.
(5) Observations on *Puccinia glumarum*.

These results have been published in different journals.

Work was also undertaken to see if *U. tritici* could infect wheat in the seedling stage. Wheat was contaminated with this fungus and sown, but at harvest no smut developed. The seed was saved, and grown for the second year, since it was thought that the mycelium of the fungus might hibernate in the seed. At the harvest of the second year, however, no smut was observed.

Other observations have also been recorded on *T. caries*, *P. glumarum*, *U. tritici*, *Phoma betae*, *H. avenae* and other fungi.

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79. CARDIFF : UNIVERSITY COLLEGE OF SOUTH WALES.

The *Hay Mixture* experiment is being concluded.

Sainfoin.—(a) Studies on the nature of the population as regards habit and persistency of the individuals of lots used in field trials in 1928 and 1929 have been continued, also on the main agronomic characters of lots sown in 1926 and 1927, on the plots. (b) Proportion of leaf, stem and flower head, and of dry weight of the lots sown in 1927 is being determined. (c) Field plots laid down in 1928 and 1929 on farms in the counties have been continued for observation. These have popularised the crop in new districts.

Lucerne.—Twenty-three lots from different sources are under observation with regard to hardiness, yield, and permanence.

Indigenous Grasses kindly supplied by the Welsh Plant Breeding Station are being compared with commercial strains for disease resistance and agronomic characters under local conditions.

Sodium Chlorate.—1 per cent. solution applied in April succeeded in destroying *Allium ursinum* above ground on a hedgebank. It also checked *Genista tinctiria,* but harmed the grass as well.

The *Potato Blight* experiment in co-operation with the Ministry Plant Pathological Laboratory and other advisory centres was repeated at the College plot.

Tomato Leaf Mould.—(a) Through the courtesy of Dr. Bewley, seed of a tomato cross raised at Cheshunt was distributed to various growers in Glamorgan and Monmouthshire for observation on its resistance and commercial qualities. (b) At a Swansea centre, proprietary sprays were used. On the whole, colloidal Bordeaux gave the most satisfactory result.

Finger-and-toe.—(i) *Brassicae.* (a) Corrosive sublimate (1/2000) on the seed bed did not give satisfactory results—but when used at transplanting gave nearly complete control. This matter needs further consideration.

(b) Watering seed bed with 10 per cent, solution of washing soda did not seem to give any control.

(ii) *Swedes.*—Danish Strains of Wilhelmsburger and Bangholm proved resistant, whereas usual varieties failed, on farms in the Gower district.

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80. HARPER ADAMS AGRICULTURAL COLLEGE.

Control of Finger and Toe Disease.—(*a*) *Mercuric Chloride* Comparative experiments showed that much better control is obtained when the solution is applied, as originally advocated, directly to the holes before planting, than by dipping the plant roots in the solution either with or without the admixture of soil. The " dipping " method gave very imperfect control of the disease.

(*b*) *Seed Bed Treatment.*—It was found that healthy seedlings could be raised on infected land by previously treating the seed bed with either 0·1 per cent. mercuric chloride or with 2 per cent. formalin.

(*c*) *Mercurous Chloride.*—Satisfactory results were again obtained by the use of this substance, and further experiments are in progress,

(*d*) *Calcium Cyanamide and Nitro Chalk* both failed to give adequate control of Finger and Toe. The former was tested on a large scale upon a swede crop as well as upon small plots of Brassicas.

Potato Blight Experiments.—A second experiment, in co-operation with other advisory centres, was carried out to ascertain any possible relationship between the incidence of Potato Blight and the age of the plant attacked.

Laboratory Work.—Research has been conducted upon certain diseases of turnip, beet and rose, and is still in progress.

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81. LEEDS UNIVERSITY.

Leaf Spot of Oats (*Helminthosporium avenae*).—The nature, incidence and symptoms of this disease, previously obscure, have been worked out, together with the life history of the causative organism.

Grey Leaf of Oats.—Treatment of this disease with Manganese Sulphate has given satisfactory results in some areas, but no complete control was obtained even with a dressing of 45 lb. per acre. Consolidation of the ground checks the disease, whilst excessive dressings of lime aggravate it.

Bracken Disease.—This work is being continued in co-operation with the West of Scotland Agricultural College and the Department of Agriculture for Scotland, Edinburgh.

Internal Rust Spot of Potatoes (*Sprain*).—Further work confirmatory of the results published in 1928 and 1929 has been completed.

Potato Sickness.—Pot experiments, in which the various combinations of eelworm and the two fungi which usually accompany the disease are being tested, were laid down in 1930, but no conclusive results were obtained that year.

Necrosis of Potatoes.—Gilbert's experiment published in 1928 has been repeated during the last two years, and the results will be collated during the winter.

Foot Rot of Peas.—A comparison of this disease with that caused by *A. pinodella* in America has been made.

Anthracnose of Begonia.—This disease—apparently new—appeared this year at Malton, and is being investigated.

A Disease of Seedling Calceolarias.—An investigation of this disease, which is apparently of bacterial origin, has been started.

Finger and Toe Disease.—The effect of treating infected soil with lime and sulphur respectively is being tested.

The histology of the abnormal roots of barley grown under acid conditions has been studied, and an examination made of the aluminium and soil acidity factors concerned.

A study of *Actinomyces* in samples of milk is in progress.

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82. MANCHESTER UNIVERSITY.

Onion White Rot (*Sclerotium cepivorum*).—Trials of commercial Onion varieties, to determine their relative resistance to this destructive disease, have again shown that southern English seed strains of certain varieties are purer, more uniform in type and far more resistant to White Rot than the extremely variable foreign stocks so often sold by seedsmen to the market growers, on account of their cheapness and availability in large quantities. It is deplored that the breeding and selection of Onion strains is not more general in England.

Potato Blight (*Phytophthora infestans*).—Observations on the relations between the incidence of Potato Blight and the condition or age of the plant foliage were continued, being part of the co-operative scheme laid down by the Plant Pathology Department of the Ministry of Agriculture. The conclusions drawn were that seasonal conditions undoubtedly determine the onset of an attack, but the exact physiological condition of the leaves at the time seems to determine their vulnerability—the older or basal leaves being generally more prone to attack than the younger or upper leaves, and the progress of the disease in the former is usually more rapid.

Potato "Sickness."—Mycological investigations have shown the presence of several fungus forms in association with Eelworms (Heterodera Schachtii) in affected roots. *Corticium* (*Rhizectonia*) *solani* was the most constantly occurring form, and at a later stage *Colletotrichum atramentarium* appeared. Microscopical sections of diseased roots showed that only the outer cortical tissues were invaded and destroyed. So far as observations have gone it is considered probable that a check to normal growth may occur in the very early stages of life of some plants in a field, owing to circumstances as yet not clearly understood, and that this, in conjunction with the organisms concerned, produces the condition known as "sickness." Early stimulation with a nitrogenous fertiliser, such as cyanamide or sulphate of ammonia, has enabled plants to partially recover and produce a fair crop of tubers.

Ergot of Rye (*Claviceps purpurea*).—Separation of Ergot grains from seed prior to sowing by means of a saline solution of definite strength has greatly reduced the percentage of infection in the resulting crop, and at the same time influenced the rate of growth and strength of the stalks. From a 1 cwt. bag of seed, $1\frac{1}{4}$ lb. of pure Ergot was separated out in this way—that is, 1·11 per cent.—which is considered a bad infestation.

Clubroot of Brassicae (*Plasmodiophora brassicae*).—The application of a 1 in 2,000 solution of corrosive sublimate to the soil of the seed bed, prior to sowing the seed, followed by a second dressing when the seedlings are 2 in. high, and finally in the holes at planting time, has given excellent control with Cauliflowers, Cabbage, Brussels Sprouts, Broccoli, and also with Wallflowers, Stocks, Candytuft, etc. Root maggots (*Chortophila brassicae*) and slugs were also effectively controlled.

Celery Blight (*Septoria apii*).—Seed and soil treatment with Formaldehyde solution has again given good results. Apart from disease control, the seedlings were more vigorous and uniform, while any moss growth on the surface of the soil in the frames was entirely prevented.

Apple Scab (*Venturia inaequalis*).—The employment of lime-sulphur as a controlling agent in this industrial area has again proved superior in every way to Bordeaux Mixture. There is less

damage to the foliage and fruits ; the control of Scab is very satisfactory, and when regularly done each year, the beneficial effects upon the tree growth are most marked and are obviously cumulative.

Apple Mildew (*Podosphaera leucotricha*).—A deficiency of potash in the soil has been found to be associated with a severe attack, and it is possible that an excess of nitrogen may also have a predisposing effect. No direct control measures have yet been discovered.

Tomato Stripe (*Bacillus lathyri*).—Sterilisation of the soil with steam has not entirely prevented an attack. The disease can apparently be carried by the seed. Preliminary experiments with treated seed sown in sterilised soil have given rather encouraging results.

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83. MIDLAND AGRICULTURAL COLLEGE.

Celery Diseases.—The investigation work on celery diseases and their control has been completed this year, and the full results are to be published shortly by the Ministry of Agriculture in a special Bulletin.

Further experiments were carried out on the *Phoma Root Rot* disease of celery seedling, and the results confirmed those obtained in previous years, viz., that this disease is seed borne and can be controlled partially by seed treatment.

Relation between the age of a potato plant and the incidence and development of Potato Blight.—An experiment on this subject was carried out in the middle of a field of potatoes. *Blight* first appeared on all the plots about the same time as it appeared on the rest of the potatoes in the field, that is, towards the end of August. The disease seemed to spread more rapidly on the plots planted first.

Foot Rot of Tomatoes (*Phytophthora sp.*).—Preliminary experiments were carried out to try to reduce the loss of plants from this disease in a greenhouse, by disinfecting the soil with 2 per cent. formalin. The disease was controlled in the early stages, but later, when the plants were put into their permanent quarters, and were from 1 to 2 feet tall, numerous cases of the disease occurred.

Mint Rust (*Puccinia Menthae.*)—An attempt was made to establish a new mint bed free from this disease by planting apparently clean, underground portions of plants in a new position. The disease appeared in the new bed in the first year. A further experiment was carried out later by burning off the old mint bed in October to try to establish a clean bed from a diseased one. The result will be known next year.

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84. NEWCASTLE : ARMSTRONG COLLEGE.

Investigations concerning the growth of potatoes in connection with the development of a seed-potato trade were continued. The crops of the Cumberland Seed Potato Growers' Association were inspected, thus enabling the members to supply seed of the highest standard, under the Association's label, to other parts of the country. An investigation organised by the Horticultural Branch of the Ministry of Agriculture was carried out jointly by the Adviser in Cumberland, Dr. Salaman at the National Institute of Botany, Cambridge, and Mr. Bryan at the Potato Testing Station, Ormskirk. Six hundred tubers, three-quarters of them from three Cumberland stocks, were each grown (by dividing each tuber into three parts) at the centres mentioned for observation of virus disease symptoms under different conditions of soil and climate. The results may afford information bearing on the question of certifying the health of potato crops grown for sale of seed. An investigation organised through the Ministry's Pathological Laboratory, and carried out by the Advisory Mycologists in various parts of the country, was conducted in Cumberland and Northumberland. This was to ascertain the age and stage of growth when potato plants become susceptible to attack by Blight. The season was favourable for this experiment, and records have been provided for the co-ordinated compilation. An investigation, continued for a second year in Westmorland and Northumberland, was made to test the influence of a single season's growth in Cambridgeshire on the vigour of a Westmorland stock of potatoes. The results of the previous trial were confirmed, the yield being only one-third of that of the parent stock ,the vigour and health lost in the more southern district not being again recovered in the north. The results have a wide practical significance.

The Adviser has continued the research on the Fusarium diseases of cereals. These diseases are more prevalent in the northern districts, but are not by any means confined to them. About the end of 1928 barley imported from the U.S.A. caused symptoms of poisoning when fed to pigs, and at the Pathological Laboratory the fungus *Gibberella Saubinettii* was found on the barley ; it was thought that this fungus might be the cause of the symptoms. At that time, the Adviser had already discovered this organism, which is one of the Fusarium group, on English-grown cereals, and has since made cultural, physiological and pathological studies, which have been published (part pending) in a scientific journal. It has been ascertained that this fungus occurs in various parts of England from the north to the south, but the frequency of its occurrence is not yet known. Since the organism shows certain differences in different parts of the world, it is proposed to continue this investigation by comparison of the English and foreign forms.

85. OXFORD UNIVERSITY.

Investigation of Apple Mildew.—The chief object was the testing, on a field scale, of the efficiency of certain spray fluids. Spray fluids containing sulphur gave promising results, but the mass of statistics collected has not yet been analysed. Sclerotial Disease of winter beans and the kindred disease of red clover have been under investigation. It has been found that clover sickness caused by *Sclerotinia trifoliarum* and *Sclerotia* disease of the bean are distinct. Both are virulent pests on their respective hosts, but the bean disease will not readily attack clover, and the clover disease attacks beans very mildly, if at all. This work is being continued. A disease of Freesia has been investigated and appears to be caused by a virus which can be transferred to healthy plants by inoculation. Further results will be available during the current year. Work has been continued on Chocolate Spot and Cercospora Spot in beans. The former is still obscure, but it is hoped to publish a preliminary note on the latter at an early date.

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86. READING UNIVERSITY.

Dry Rot and Canker Disease of Swedes.—The germinator method of testing stocks of seed for infection with the fungus (*Phoma Lingam*) has been found, after extensive tests, to be much more satisfactory than growing seedlings under moist conditions in sterilised soil, and than the agar plate method. It requires much less skilled technique than the latter, and could be used satisfactorily by the higher grade of commercial seed tester.

Two trade samples of seed have been found with the unusually high infections of 1 and 3 per cent. The work has continued to be hampered by weather conditions unfavourable to the development and spread of the diseases at the critical times. Soil, considered in a broad sense, continues to be the most important source of infection for the worst, and disastrous, cases of the disease in the field, although high percentages of disease infection in the seed can be obtained experimentally by spraying with spore suspensions at the critical time.

Considerable evidence of the occurrence of the disease in " plant beds " has been accumulated—a phase not previously recognised by the trade.

Brassica alba, occurring freely as a weed, has been found in Dorset swede fields infected with what appears to be *Phoma Lingam*. This probably plays a large part in the carrying over of the disease.

Shanking in Tulips.—Phytophthora erythroseptica has been isolated from a serious case of " Shanking " in forced Tulips, and inoculation experiments are in hand.

Co-operative Experiment on Potato Blight.—Blight did not appear on the "date of planting" plots until late in August, and the incidence of the disease bore no significant relation to the age of the haulm.

Bunt in Wheat.—The new Cotton Industry fungicide—"Shirlan"—had no effect on Bunt at 0·1 and 0·2 per cent. strengths applied at the rate of 2 gallons per bushel. Further results on the relation of "spore load" to the amount of disease in the crop have been obtained.

Negative results have been obtained in testing manganese sulphate as a "cure" for *Physiological Heart Rot* of Sugar Beet, and for *Spinach Yellows* (non-mosaic). Negative results were also obtained from inoculation experiments with *Pestalotia, Phomopsis* and *Diaporthe* in Rhododendrons.

Cultural experiments indicate that *Geotrichum roseum* is a stage of the grass fungus, *Corticium fuciforme.*

87. SEALE HAYNE AGRICULTURAL COLLEGE.

Potato Blight.—The co-operative experiment planned by the Plant Pathological Laboratory, Harpenden, on the relation of the age of potato plants to the incidence of Blight was repeated by means of three series of plots. The results showed that the early plantings succumbed more quickly than the later ones.

Detailed observations were made of the weather in relation to the appearance and progress of the disease, and the great importance of periods of high relative humidity was clearly shown.

Control of Black Leg of Mangolds.—Seed from fifteen different farms was treated, the seed disinfectants used being uspulun, ceresan and copper carbonate. In most cases black leg was absent and *Phoma Betae* was not observed. The seed treatment completely failed to control *Pythium De Baryanum.* The hydrogen ion concentration was obtained by the advisory chemist for each soil, and the figures indicate that *Pythium* is of no importance where the pH is not less than 6.

Ascochyta Diseases of Peas and Beans.—The results have shown that the form of *Ascochyta* on broad beans is to be considered as a distinct species, *Ascochyta Fabae,* Speg.

Control of Tulip Fire.—Previous results have been confirmed and extended, and an account is being prepared for publication.

Narcissus Diseases.—Experiments and observations have been continued on *Ramularia Vallisumbrosae, Stagonospora Curtisii,* Yellow Stripe, and the Fusarium Bulb Rots.

Mystrosporium adustum on Iris.—Inoculation experiments have been successfully carried out.

88. SOUTH EASTERN AGRICULTURAL COLLEGE.

Downy Mildew of the Hop (*Pseudoperonospora Humuli*).—Investigations concerning the control of this disease by spraying with home-made Bordeaux mixture have been continued, and it has been established that three sprayings, properly applied, will prevent cone-infection. The effect of spraying when the plants are in " burr " has been studied. The partial breakdown of the resistance hitherto shown by the cones of the variety Fuggles has been investigated. A rot of the strap-cuts caused by the fungus has been studied.

Virus Diseases of the Hop.—Under a grant from the Ministry of Agriculture investigations concerning mosaic disease by means of grafting have been continued for the fourth consecutive season. It has been ascertained that the commercial varieties Fuggles, Colgate and Tolhurst are resistant to mosaic disease and are, or may become, " carriers " of it. Experiments using the inarching method of grafting have been carried out. The " Chlorotic disease " has been shown to be transmissible by rubbing healthy leaves with sap from infected plants. " Split-leaf " in an aggravated form and other apparently new virus diseases have been studied.

A New (*Verticillium*) *Disease of Mushrooms.*—Mr. W. M. Ware has investigated a disease affecting cultivated mushrooms on a farm in Kent. A species of *Verticillium* was isolated, and evidence was obtained, by means of pure and single spore cultures, that this is the cause of the disease. Methods of control have also been studied.

Apple " Scab."—In collaboration with the Chemical Research Department, large scale spraying experiments have been continued at (1) the College Farm, and (2) a farm at Teynham, Kent. Plots of four commercial varieties of apples have been sprayed with either home-made Bordeaux mixture or lime-sulphur. Several tons of apples from sprayed and unsprayed plots have been graded by hand to determine the amount of " scab " present.

Experiments with Fungicides.—In collaboration with the Chemical Research Department, biologically controlled experiments with various fungicides have been carried out. The fungicidal properties of certain vegetable oils (e.g., olive, sesame and cotton seed) have been discovered.

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89. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

Research work is directed mainly to the study of pasture problems, and includes :—

(1) Investigations on semi-natural hill pastures.
(2) Experiments with sown grasses and clovers and seeds mixtures.

Hill Pastures.—These are under investigation at Boghall Glen. At present investigations are confined mainly to the grassy types of hill grazing. The botanical characters and soil relationships of the various types occurring in the glen are being studied. Experiments are in progress in regard to the effect of manures on the herbage. The effects of irrigation with spring water and of drainage of certain types are also being investigated.

Experiments upon the control of bracken are in progress.

Seeds Mixtures, etc.—A series of seeds mixtures has been sown out in small plots for study of the suitability of various species for inclusion in seeds mixtures. Experiments on a field scale have also been begun at Boghall. Pure plots of a number of species and strains of grasses and clovers are under observation.

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90. GLASGOW : WEST OF SCOTLAND AGRICULTURAL COLLEGE.

Plant Husbandry.

Eelworm Disease of Potatoes.—The research work on this trouble was further continued during the year, mainly, however, with a view to obtaining satisfactory control in the field. Unfortunately, the control measures which were promising from preliminary tests, such as (1) the growing of a crop of chicory and mustard, and (2) the application of animal oil to the ground previous to taking potatoes, proved of no avail when tested out in the field.

Work on this disease is reviewed (*a*) in a short article which appeared in the October issue of the Scottish Journal of Agriculture, Vol. XIII, No. 4—An Eelworm Disease of Potatoes caused by *Heterodera Schachtii* and (*b*) in a Research Bulletin of the College. This contains a full report of the investigations, and deals with the problem in all its aspects.

Yellow Leaf or Helminthosporium Disease of Oats.—Investigations were carried a step further by testing, on a large scale, the value of treating the seed before sowing with the most practicable and at the same time the most efficient disinfectant, namely Ceresan.

A considerable quantity of seed was treated with Ceresan by farmers in the South-West of Scotland, and the results obtained have fully borne out those recorded for the small scale experimental plots. In every case the farmer carried out the experiment himself and selected his own seed, so that there could be no criticism that undue care had been taken with the treatment, or that the seed selected was not of average quality. After the crop had brairded, a sufficient number of counts were made of the plants to get an average established on the treated and untreated sections of the field. In every case the braird on the treated section was much healthier, more uniform and more vigorous than that on the untreated section.

The average increase in establishment due to seed treatment at eight centres was 91 per cent., in other words there were almost twice the number of plants on the treated section as there were on the untreated, and further, the percentage of plants visibly affected with leaf stripe was 28 on the latter as compared with four on the former.

At some centres home grown treated and untreated seed was compared with new oat seed from the East of Scotland. The establishment of the home treated seed in these experiments was 110 per cent. better than the untreated home oats and 57 per cent. superior to the Lothian treated seed.

A short account of this work appeared in the July issue of the Scottish Journal of Agriculture: "Yellow Leaf or Stripe of Oats;" Journal of the Scottish Board of Agriculture, Vol. XIII, No. 3.

Dry Rot in Swedes and Head Blight of Timothy.—Work into these troubles was further pursued, but is not sufficiently far advanced to warrant publication of findings.

O.

VETERINARY SCIENCE.

91. BANGOR : UNIVERSITY COLLEGE OF NORTH WALES.

The causes of occasional intolerance to dosage with carbon tetrachloride among ruminants.—In the absence of special financial assistance this investigation could only be continued on a very limited scale, made possible by a small locally provided fund and by the co-operation of Professor E. C. Dodds, of the Courtauld Institute of Biochemistry, Middlesex Hospital.

The experiments were made on cattle, and intolerant animals were readily obtained among a group of bullocks being fed at the College Farm. A single dose of 40 c.c. killed one of these bullocks within ten hours—before post-dosage blood samples could be had. A second bullock was kept under constant observation after dosage with 15 c.c. It died at the forty-second hour. A full record of the symptoms was obtained and a thorough post-mortem examination made. Blood samples for complete biochemical analysis were taken at intervals throughout the experiment.

Unfortunately, these losses so depleted the small fund available that further work, on the influence of a change of diet on tolerance, could not be undertaken in view of the risk involved.

Contagious Pneumonia in Sheep.—A form of contagious pneumonia which occurs sporadically among sheep in the district is under investigation. It has been found that the inoculation of *B. ovisepticus* antiserum is of value. Serious cases have made quite rapid recovery following its use. The inoculation of only the affected and suspected sheep in each flock has terminated the outbreaks so far encountered.

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92. CARDIFF : UNIVERSITY COLLEGE OF SOUTH WALES AND MONMOUTHSHIRE.

Among sheep, the attention of the Department has been directed mainly to *Broncho-Pneumonia,* which has been closely related to infestation by Oestrus larvae ; *Septic Pneumonia* in lambs—traced to udder infection in the ewes ; progressive *Anaemia* without (so far) demonstrable cause, experimental treatment of which by inoculation has been giving encouraging results ; and a comparative investigation of *Braxy* and the diseases known locally as *Planet* and *Strike.*

In Poultry, *Fowl Typhoid, Bacillary White Diarrhoea, Fowl Pox, Coccidiosis, Tuberculosis, Roup,* etc., etc., have been dealt with. In the cases of Fowl Typhoid and Fowl Pox, preventive vaccines prepared by the Poultry Department of the Ministry of Agriculture have been introduced over a wide area with most satisfactory results.

The principal diseases of cattle in which the Department has been interested this past season have been *Johne's Disease, Red Water,* and *Contagious Abortion,* with special reference to its common sequel of barrenness.

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93. HARPER ADAMS AGRICULTURAL COLLEGE.

Coccidiosis.—The treatment and control of " Avian Coccidiosis " occupied the greatest part of the time possible for investigations. The main points are as follows :—

That chemical disinfection is of no value as shown by laboratory and inoculation experiments. Some oöcyst have powers of resistance to climatic conditions, putrefaction, etc. Sanitary measures have a controlling action limited in its effectiveness.

The use of Iodine in milk added to the drinking water in combination with sanitary measures was advised following experimental results.

Adult coccidiosis was shown to be prevalent amongst flocks and data given in treatment and control of this condition.

Fowl Pox.—3,600 vaccinations were carried out in the control of this disease, using the vaccine prepared by the Ministry of Agriculture, and the results observed. No fall in egg yield occurred, and excellent results were obtained.

" Blows " in Rabbits.—Experiments are in progress with regard to this disease, and an attempt is being made to ascertain the incidence amongst rabbits.

Pseudo tuberculosis in Rabbits.—Also under experiment. Some results have been obtained, but further data is to be collected before any conclusions can be reached.

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94. LEEDS UNIVERSITY.

" Ray " in Lambs.—A controlled experiment was conducted in the Spring of 1929, and repeated in 1930 to test the value of Lamb Dysentery Serum (Wellcome) for the prevention of so-called " Ray " in newly born lambs in the Craven district of Yorkshire. In each year some 500 lambs were injected with the serum and about an equal number of lambs on the same farms not injected kept as controls. The serum proved to be very effective in the prevention of the disease. The serum also proved itself valuable in the treatment of actual cases of the diseases as several farmers injected control lambs with the serum after they had developed the disease, and in the majority of cases the lambs recovered.

Mineral Deficiency in Sheep.—The chief object of the investigation was to obtain evidence as to the possible influence of a mineral

deficiency on the incidence of a disease known locally as " Tremblings " or " Moss Illness " in lambing ewes. The investigation was inconclusive, but some information was obtained as to the value of minerals in the improvement of the ewes and lambs.

95. LIVERPOOL UNIVERSITY : DEPARTMENT OF VETERINARY PATHOLOGY.

The two research problems which have received most attention during the year have been the vaccination of cattle against Tuberculosis by means of the B.C.G. Vaccine and Johne's Disease.

As far as observations have gone upon the value of the Calmette Guerin vaccine under ordinary farm conditions, no case has been met with which refutes the claim made for it by the originators.

A number of vaccinated animals which were subjected to the tuberculin test all gave positive reactions.

An investigation of the types of secondary bacteria, which occur in tuberculous mastitis showed that staphylococci, streptococci and diphtheroids were the commonest secondary invaders in the cases under examination.

Research in Johne's Disease has been mainly conducted upon the value of a diagnostic agent for the detection of the disease in its early stages. Over seven hundred tests have been carried out during the year upon cattle in herds which were known to be infected with the disease. Twenty-one reactors have been subjected to post mortem examination, lesions which were indistinguishable from those of Johne's disease microscopically were found in all except one case, microscopic examination of material from the lesions showed Johne's Disease bacilli to be present in eleven cases.

Pregnancy Disease in Ewes.—Of the 1930 cases, seven were from the North Riding, three from the West Riding, four from the East Riding, and one from Lancashire. From these cases blood and/or urine was collected for biochemical examination, and in most cases a postmorten examination was made. In addition, in 1930 the urine and blood of 11 normal sheep were examined biochemically. The figures obtained in these sheep were such that they lead one to question whether undue significance has been attached to results obtained in the biochemical examination of blood. The blood sugar in these sheep varied from 37·0 to 328·0 mgs. per cent., the blood calcium varied from 2·2 to 7·7 mgs. per cent., and the non-protein nitrogen from 14·0 to 93·0 mgs. per cent. Large variations were also seen in the biochemical tests of the blood of affected sheep.

The investigation will be continued for one more season, that of 1931, after which further application for a grant to continue this work will not be made. It will, therefore, be more useful to await the completion of the 1931 work before issuing a detailed report on this disease with the results of the whole investigation.

96. NEWCASTLE : ARMSTRONG COLLEGE.

The Adviser in Veterinary Science has continued his studies on certain diseases of sheep. Field experiments were conducted to test the value of a single dose vaccine in the prevention of Braxy or sickness in young sheep. Of 1,186 hoggs inoculated with this vaccine, on 11 different farms, 13 or 1·1 per cent. died from the disease. On these same farms 366 young sheep were specially marked and left untreated, and of this number 45 or 12·8 per cent. died from Braxy. While experiments are being extended it seems likely that this method will supersede the more troublesome method, which involves two inoculations at an interval of 14 days. Lectures and advice have been given on the subject of lamb dysentery. Vaccination of pregnant ewes or the serum inoculation of newly-born lambs coupled with good hygiene are accepted preventives against dysentery in lambs. The incidence of joint-ill, grass-ill and parasitic infestations in lambs continues, and they are receiving attention. Stock poisoning cases have been investigated with the assistance of Mr. Thomas. The Adviser and Mr. Henderson have again collaborated in the study of certain diseases of sheep and cattle, and the disease known as " grass-ill " is now believed to be preventable.

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97. SOUTH EASTERN AGRICULTURAL COLLEGE.

The work on " Struck," a fatal disease of sheep which causes great loss among the flocks on the Romney Marsh, Kent, has been directed towards elucidating the aetiology of the disease. " Struck " was formerly regarded as a type of black-quarter, but investigations have shown that these changes in the carcase which resemble black-quarter are due to the post-mortem generation of *B. paludis* in the muscular tissues.

It has been shown that " Struck " is due to the absorption from the alimentary tract of *B. paludis* toxin. The toxin causes necrosis of the intestinal mucous membrane, becomes absorbed into the peritonial cavity, and produces peritonitis and toxaemia.

The bacteriology of parturient gas gangrene of ewes and of wound gas gangrene of lambs and sheep is being investigated. *B. Chauvoei* appears to be the micro-organism responsible for the majority of the cases.

Contagious abortion is being controlled and eradicated from a number of herds.

P.

DAIRY BACTERIOLOGY.

98. ABERYSTWYTH : UNIVERSITY COLLEGE OF WALES.

Bacteriological Efficiency of Milking Machines.—This work has been continued with two types of machines. An article on this work will be published before the end of the year.

The Quality of Welsh Farm Butter.—More data with reference to the scoring, grading, and keeping quality of butter have been obtained. An idea of the quality to expect during the different seasons of the year has been obtained. The comparison of Welsh, Danish, and New Zealand butter has also been continued.

In conjunction with the Dairy Staff problems connected with cream separation, cream ripening, and butter making are being investigated.

Examination of Sweet and Ripened Cream.—The work on butter has led to the investigation of cream during the various stages of ripening. Methods of cream grading have been studied, and an attempt is being made to devise a technique for the routine examination of the flora. Cream samples have been found to be excessively contaminated with coliform organisms.

Mr. G. T. Morgan, the Senior Dairy Instructor, is at present investigating the qualitative and quantitative distribution of micro-organisms in cream during various stages of ripening.

Cheese Starters.—Starters from the College Dairy have been examined with a view of devising a technique for routine examination. The following tests have been found useful :—

(1) Microscopic examination.
(2) Fermentation at 37°C.
(3) Presence or absence of Coliform organisms.
(4) Presence or absence of yeasts on acidified malt agar incubated at 22°C.
(5) Presence or absence of liquefiers on nutrient gelatine at 22°C.
(6) Anaerobic spore test.

The Microflora of Ice-cream.—The study on the bacterial content of ice-cream has been continued. Although the local manufacturers, who are co-operating in this work, generally heat the milk or cream the mixture is not pasteurized.

Excessive contamination has been found to occur during the mixing. Spore formers of the *Bacillus subtilis* group are very abundant in some of the samples.

Miss Hetty Jones is at present working on the prevalence of thermophilic and thermoduric organisms in raw and pasteurized milk.

99. BANGOR : UNIVERSITY COLLEGE OF NORTH WALES.

Investigation into a case of high bacterial counts and presence of coliform organisms in pasteurized milk revealed the fact that the brine cooler was responsible, owing to inefficient sterilisation. Steam-tight covers were fitted, and efficient sterilisation being carried out no further trouble was experienced.

Other investigations related to taints in milk and butter, mastitis and water supplies.

During the Butter Competition of 1929, it was found that the keeping quality of many of the samples was poor in comparison with the high standard of the butter judged when fresh. In view of this fact, an attempt is being made to introduce the use of " starter " on some of the butter-making farms, the object being to improve both flavour and keeping quality. " Starter " is supplied from the laboratory, and samples of the butter from (a) naturally ripened cream, and (b) cream ripened with " starter " are tested periodically for flavour, texture and keeping quality.

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100. BRISTOL UNIVERSITY.

A survey of cheese-making farms in the West of England was made by the Dairy Bacteriologist as a result of complaints received of a taint in Somerset cheese, similar in character to the taint which was very widespread in Scotland in 1928.

Arising out of the Clean Milk Competitions and the Wiltshire Register of Accredited Milk Producers, the question of high counts in milk samples due to high temperature conditions during transit to the laboratory in hot weather has again asserted itself. That the problem is a very real one has been demonstrated by a preliminary investigation conducted by the Dairy Bacteriologist in conjunction with the Agricultural Organiser for Wiltshire, and possible methods of mitigating this trouble are being studied.

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101. HARPER ADAMS AGRICULTURAL COLLEGE

Some work was done on the problem of slow working cheese, which is prevalent and causing much loss in Shropshire. Attention was paid to purity of starter and quality of the milk. Little relief was obtained by this method.

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102. LEEDS UNIVERSITY.

The presence of coliform organisms in milk produced on graded farms.—Five cases of this nature were investigated. In two cases inefficient cleansing and sterilising of the milking machine was the cause. In one case difficulty in sterilising a fixed cooler was responsible, and in one case inefficient sterilisation of the utensils.

Frothiness in Cream.—This formed an interesting investigation. On this farm a large quantity of cream was being produced by allowing milk to stand in large shallow vats. After the milk had been standing for 24 hours it became very frothy. The cream, however, " kept " well, although after two or three days it developed a slightly fishy taste. The frothiness and fishy taste was found to be due to a slime producing strain of *Bacterium fluorescens* growing in conjunction with a gas-producing yeast. Both organisms were traced to the water supply.

Poor Keeping Quality of Milk.—This was found to be due in many cases to general uncleanliness both in the cowshed and the dairy.

Slimy Milk.—Two cases of slimy milk were investigated. In each case the sliminess was found to be due to a capsulated strain of *Bacillus aerogenes.*

Latent Mastitis and Abnormal Udder Flora.—Two cases of Mastitis and one case of an abnormal udder flora have been investigated. All three cases were on farms producing " Certified " milk.

The investigation into the frequency of occurrence, and the effects produced by, species of Actinomyces in milk has been continued.

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103. MIDLAND AGRICULTURAL COLLEGE.

Ropy Milk.—In every instance of ropy milk epidemics, water has been found to be the initial source of infection. In three instances the ropy organisms were isolated from running streams. A detailed study of the source of infection of one of these streams was made, and it was traced to a point about two miles up stream from the farm. At this point the stream was polluted with sewage from an adjoining village.

Oily Milk.—A case of oiliness in milk due to copper was traced to the combined effect of a copper gauze strainer and a slightly worn regenerative heater. After the passage of milk over one of these utensils separately oiliness did not develop. Oiliness was obvious when in the treatment of the milk the two utensils were placed in series.

Fishy Milk.—Fishiness in the bulk milk from a herd during May was traced to a single cow. This cow was yielding approximately 4 gallons a day, and was out to pasture, no concentrates being fed.

Bacteriologically the udder appeared perfectly normal, and the cow was reported to be healthy by a veterinary surgeon. Butter made from the milk was devoid of any trace of fishiness.

Unsuccessful attempts were made to reproduce the flavour by growing mixed and pure cultures of bacteria isolated from the quarters in raw and sterile skim milk, and in such milks when a trace of egg lecithin, choline or betaine was added.

The fishiness disappeared from the milk towards the end of the cow's lactation period.

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104. NEWCASTLE : ARMSTRONG COLLEGE.

Eradication of Bovine Tuberculosis.—This work (previously reported) carried out in conjunction with the Borough of Berwick-on-Tweed has, of necessity, been suspended. It is hoped that it may be continued in the coming year.

Brucella abortus Infections.—A survey of the prevalence of this organism in the milk of the Northern Province is in progress. With the co-operation of the Veterinary Adviser experimental work concerning the elimination of contagious abortion has been commenced.

Anaerobic Infections.—A study of the characteristics of certain anaerobes has been in progress for two years, and certain results are published. Further observations are embodied in a thesis accepted in June, 1930, by this University.

Polyarthritis Neonatorum.—Identification and classification of organisms isolated from cases of this disease is still in progress.

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105. READING UNIVERSITY.

Reading Duplicate Testing Scheme.—Each week three samples of afternoon's milk from the herd at Church Farm, Shinfield, are divided into 11 6-oz. portions, nine of which are sent by post to different advisory centres and two to the Advisory Laboratory at the National Institute for Research in Dairying. All portions are tested at 24 hours old for bacterial count, presence or absence of *Bacillus coli*, keeping quality and fat percentage, and the results returned to the National Institute for Research in Dairying. Up to the time of writing the results of 335 samples are complete.

Reading Correlation Scheme.—Advisory Bacteriologists at all centres send to the National Institute for Research in Dairying, copies of the results of all samples tested in connection with clean milk competitions. This has been done with a view to collecting the data at a centre where they will be available to any dairy bacteriologist or statistician who may wish to carry out an investigation involving

the analysis of large numbers of samples which have been sampled and tested under conditions as nearly similar as possible.

The Keeping Quality of Morning and Evening Samples of Milk.—A preliminary analysis of samples of milk produced on different farms indicated that the keeping quality of morning samples was greater than that of evening samples. It was felt that the number of factors involved in such an analysis would be reduced if an analysis was made of the morning and evening milk from the same herd. This was done and the results indicate that the morning samples do keep significantly longer than evening samples. The number of samples was limited and further tests are being done with a view to a future analysis.

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106. SEALE HAYNE AGRICULTURAL COLLEGE.

The investigational work commenced last year on the infection of milk with spore-forming bacteria which cause trouble in the manufacture of scalded cream has been continued. As was found last year the water supply seems to be the commonest source of infection with these organisms.

Mastitis in Dairy Herds.—It has been pointed out by the Advisory Bacteriologist for the Bristol area that when there are a large number of chromogenic bacteria staphylococci on agar plates, there is an indication of some form of udder trouble in a herd. Several attempts have been made to verify this, and with some success.

Farm Water Supplies.—Several cases of high bacterial counts, where every possible care in production is taken, have been traced to the use of polluted water used for washing the cows' udders previous to milking.

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107. SOUTH EASTERN AGRICULTURAL COLLEGE.

In Wye Province the Clean Milk Competitions are organised by the County Staff. Testing these samples, however, continues to form about two-thirds of the work and income of the Laboratory. General advisory work has increased, but no cases of note occurred. The total of samples (apart from competitions) has increased slightly, and this season 40 per cent. of such samples came from dairymen. This may be due in part to visits made to dairy firms to stimulate their interest in the bacteriological aspect of milk. A few samples were tested for local authorities, and exhibitions were staged at agricultural shows in the area.

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108. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

Clean Milk Production.—The enquiries received included requests for information on the bacterial content of samples of milk and cream, the causes of certain milk taints, the sources of abnormal bacterial contamination of milk samples, licences for production of graded milks, etc. During the year, 328 samples of milk and cream were examined and reported upon. As in previous years, the majority of the samples were graded milks.

An interesting case of a persistent high coli count in certified milk was investigated and traced to two cows in the herd. In each case, one quarter of the udder yielded milk containing coliform organisms.

The micrococcus which produced an odour resembling that of amyl alcohol in milk (*see* last report) was found on the skin of the cows. Contamination of the cows' skin originated from contact with a coating of manure and other material on the floor of the byre. When the byre floor was washed, scraped, and thoroughly disinfected, the taint disappeared.

Life Cycle of the Butyric Acid Bacillus.—The experimental work was completed. A study of stock strains of many of the types obtained from this organism and of the literature on the subject yielded important evidence corroborative of the conclusions already arrived at. The results were prepared for publication.

Miscellaneous Subjects.—A number of bacterial plant diseases were investigated, and observations were made on the inoculation and cultivation of lucerne and other leguminous crops.

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109. GLASGOW : WEST OF SCOTLAND AGRICULTURAL COLLEGE.

Milk Production.

The greater portion of the time of the Department is taken up with feeding experiments and a study of the records collected by the Scottish Milk Records Association. The latter are used in the investigation of breeding and management problems.

During the year some interesting results have been obtained. It was found that up to 80 lb. of swedes can be fed daily to milking cows with economical results, while an allowance of 20 per cent. of digestible crude protein in the concentrate mixture gave greater milk yields than 15 per cent.

In the study of milk records it has been found that in the early years of milk recording only a small percentage of bulls were of value for increasing the milk production of the herds in which

they were used. A survey in the Rhinns of Galloway shows that in certain areas bloat, or hoven, is a severe tax on the dairy industry.

Milk Utilization.

Experimental and Laboratory Work.—The following investigations which have a direct bearing on the purity of milk and on the manufacture of farm and factory cheese were carried out during the past season. In all ninety experimental cheeses were made.

Slow-working in cheesemaking.—The effect of certain restraining factors (e.g., mammitis infected milk : blood serum) and the ameliorative effect of activators, was studied at some length—30 experimental cheeses being made in this group.

Relative merits of pure culture starters in cheesemaking using single and combined strains of lactic acid bacteria, e.g., (*a*) *Str. cremoris*, (*b*) *Str. cremoris* + *Str. lactis*, (*c*) *Str. cremoris* + *B. acidophilus*. The latter combination was found to be of considerable utility in cheesemaking. Thirty-four cheeses were included in this group.

The behaviour of milk of single cows and of selected groups of cows in cheesemaking.—The character of the cheese made from the milk of (*a*) those cows giving apparently normal, and (*b*) those giving abnormally reacting milk, was determined. Twenty cheeses were included in this group.

Special types of discolouration in cheddar cheese, e.g., rusty spot and pink type of discolouration observed in Scottish and New Zealand cheese. Six cheeses were represented in this group.

Milking Machine Investigations.—The relative merits—from a bacteriological standpoint—of machine and of hand-drawn milk were determined in a series of carefully conducted trials with the cows of the Experiment Station herd, and the data obtained partly embodied in a section of Bulletin 121 of the College. The chief sources of contamination in machine milking appear to be the moisture trap, the rubber conducting tubes and the teat cups. Methods of cleaning and sterilization which, when carefully employed result in a low bacterial count are set forth. Further work on milking machines is contemplated.

Germicidal action of raw milk.—The restraining action of raw milk on bacterial development was studied in some detail, the relative bacterial counts being determined both by the plate method and by the direct microscopic count. The results indicate that the normal milk of individual cows has no bactericidal action, and that so far as the lactic acid bacteria are concerned, it does not even exert any perceptible restraining action. In other words, fresh raw milk when normal does not appear to hinder the development of starter organisms. If the lactic acid fermentation in cheese is

suspended for any interval, it is because the milk, while apparently physically sound, is abnormal in some respect, more especially from a biochemical standpoint.

Putrefactive organisms occurring in dairy products.—Work on putrefactive bacteria which have been found in cheese and which appear to be responsible for the well-known taint is being continued. The isolation in pure culture of these organisms from infected material offers considerable difficulties. A rapid method for determining the presence of putrefactive bacteria in infected material and the action of these bacteria on cheese substance has been worked out. This method, which appears to be of considerable value, will economise expense in the necessary experimental work on cheese.

Starter Service.—Over 4,000 pure culture starters were issued during the past year.

Q.

ECONOMICS.

110. ABERYSTWYTH : UNIVERSITY COLLEGE OF WALES.

Information obtained and suggestions made by the Department as a result of research and investigational work have assisted in bringing into prominence three possible lines of improvement in Welsh farming, namely, development of methods of livestock marketing ; the better utilisation of milk on stock-raising farms and the improvement of preparation and organisation of butter for sale ; and development of methods of marketing wool. In each case, there is need of changes and improvements ; and although progress is slow there is much scrutiny of present methods and consideration of changes. As there has been rather unsatisfactory response to recent possibilities of profitable poultry enterprises some study of conditions of egg and poultry production has been conducted and efforts have been made to draw attention to certain weaknesses in existing methods. Accounts kept for farmers and for investigational purposes have created considerable interest amongst the groups concerned. There are indications that in Wales the farmers who obtain the best financial returns are those with the higher standards of farming and the higher outputs. But individual farmers are anxious to obtain comments and suggestions on their methods and on their results as shown by accounts. An attempt to forecast prices of pigs has not attained complete success, but over one period a forecast formula which showed quite accurately the direction of all changes in actual prices also showed a degree of 80 per cent. accuracy in the fit of the forecasted and the actual prices.

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111. BRISTOL UNIVERSITY.

The general programme of work has remained unchanged during the year, except that more attention has been given to work based upon simple financial accounts than upon cost accounts. There are now 235 of the former and 9 of the latter type of farm account. The chief reasons for the increased emphasis upon financial accounts are because (*a*) many more farmers can avail themselves of the services of the economics branch, and (*b*) the few cost accounts occupy a disproportionate amount of time and expense, and the resultant costs are so widely different that little use can be made of them for advising other farmers. It is considered that much more useful work can be done by studying results of the farms as a whole, and by means of suitable methods of grouping to give farmers comparative results over a much wider area. Moreover, a fairly large number of farm accounts enables one to obtain more reliable averages and to make use of further statistical methods.

During the year the special investigation into the cost of production of sugar beet on 40 farms in Hereford and Worcestershire was continued for the fourth and last year, and the results forwarded to the Agricultural Economics Research Institute, Oxford.

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112. CAMBRIDGE UNIVERSITY.

Three new investigations, based on the survey method, were commenced during the year. The first of these relates to the 1930 sugar beet crop and concerns some 50 farms distributed evenly between the fen and high land soils. The second enquiry refers to wheat production on fen, loam and clay soils, the sample comprising approximately 100 fields and relating to the 1930 crop. The third, and most important investigation, may be described as an economic survey of the agriculture of one county in the Province.

The County selected for this survey is Hertfordshire ; the reason for this choice being that the County Organiser (Mr. J. Hunter-Smith) offered to co-operate in the taking of the necessary records. The sample for investigation has been selected in the following manner. The Ministry of Agriculture's list of occupiers of holdings of 1 acre and more was arranged by Parishes in alphabetical order. Every third name was then selected. From this selection were separated all those holdings known to be not genuinely agricultural undertakings (e.g., private gardens, public house yards, recreation grounds, etc.). The remainder (comprising about 700 holdings) are all being visited. It is anticipated that records will be obtained from about one-half of these.

The records being collected refer to yields, prices, sales, purchases, costs, expenses and valuations. It is believed that valuable information relating to the economy of different types and sizes of farms will in this way be obtained.

Three Reports have been issued during the year. The first of these (Report No. 14, The Seasonal Variation in Farm Labour Requirements) is based on costings records and relates to the seasonal distribution of farm labour requirements. Illustrated by numerous diagrams this publication shows the amount of labour required by those crops and types of livestock common to the Province, and the seasonal variation of the demands which they make on the farm personnel. Report No. 15 (" Factors affecting the price of Potatoes in Great Britain ") is a statistical investigation of the factors affecting the price of potatoes in Great Britain. The data on which the author's conclusions are based cover the period 1884 to 1930. The third report (No. 16, " Sugar Beet in the Eastern Counties, 1929 "), issued during the year, summarises the results emerging from the special sugar beet investigation commenced in 1926. In addition to much statistical information relating to costs of production (referring to over 7,000 acres of beet), a considerable amount of space is devoted to comparison of the effects of different systems of management and methods of production.

113. HARPER ADAMS AGRICULTURAL COLLEGE, NEWPORT, SALOP.

Costings.—Five farms were fully costed. The costings have been supervised on two farms where the work of analysis is carried out throughout by the farmer.

Financial Accounts.—These have been collected from the same farms, and by the same methods as last year, though partly owing to the changes of farm and other causes of a like nature outside the control of the Department, and partly owing to the time taken in their collection, the number of financial accounts was reduced to 35.

No. of farms.	*Total arable acreage.*	*Total pasture acreage.*	*Total acreage.*
35	5,201	8,597	13,798

The collection of these accounts will be continued and probably extended. There seems need for a meeting of those interested in this form of research to discuss methods both of collection and tabulation of these accounts. They certainly have some advantages. In the first place, almost all farmers keep some form of account, and it is almost always possible to reduce these to a comparable basis if it is thought desirable. The material is there in very large quantities, and can be used for a great number of purposes. Such bias as is there, is all in the same direction. It is a debatable point as to whether it is better to attempt to get a uniform system of book-keeping started before an investigation, or whether to reduce the accounts which already exist to a comparable basis. A much more reliable sample can be obtained anyway, and the method certainly deserves fuller examination.

Survey Costs.—The survey of beet costs and returns was continued. The number of individual costs completed was 118, covering 1,132 acres of beet. Close co-operation with the Advisory Chemist was again maintained.

By far the most useful work done by the Department has been the survey costing of sugar beet. Not only has it brought the Adviser into touch with the greatest number of farms, but it has showed the greatest return for the money expended. It was felt last year that all the useful work possible on this crop had been done, but in view of the unsettled and unsatisfactory state of the industry from the farmer's point of view it has been decided to co-operate with Oxford and cost twenty of the largest growers for the duration of the subsidy.

It is on these lines that the Department hopes to develop for the next few years. Survey costing of Potatoes, Carrots, Mangolds and Swedes is in progress on 50 farms in the Province this year.

Poultry Survey.—A survey of the costs and return of Poultry Husbandry has been evolved and planned to start on October 1st.

It was devised in full co-operation with the County Poultry Instructors, and farms of the undermentioned types are included in each of the co-operating centres :—

Two commercial egg farms.
Two general farms in which poultry is a separate unit.
Two general farms with barn door flocks.
Two small holding plants.

It was felt that such an enquiry would be useless without the inclusion of Lancashire and Cheshire, and with the co-operation of the Adviser to the North-Western Province the necessary farms have been included from those counties. There is every probability that the Northern provinces will conduct a survey on similar lines.

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114. LEEDS UNIVERSITY.

(*a*) *General Farm Management.*—This investigation is based on the records of 86 commercial farms covering more than 24,000 acres, the records being kept on a modified costings system on the lines of that employed by Dr. Larsen of Denmark. The records over a series of years show that the suggestions which have been made to the individual farmers have been of practical value.

(*b*) *Commodity Studies.* (1) *Peas for Picking Green.*—An examination is being made into the special circumstances associated with the growing and marketing of this crop in Yorkshire, which has the second largest acreage under this crop in the country.

(2) *Flax.*—There has recently been a revival in Flax Growing in the Selby District. Since 1928 an investigation has been in progress into the cost of growing the crop, the economic return to be expected from it, and the effect of the crop on the fertility of the holding.

(3) *Potatoes.*—Yorkshire offers a large variety of conditions of culture, both as regards soil and situation, and the low prices that have ruled for this crop in the past two years make the investigation into the economic possibilities of the crop of peculiar importance at the present time.

(4) *Economics of Sheep Husbandry.*—Alongside a study of the world position of sheep a local economic study of sheep farming in Yorkshire is being made, which comprises hill flocks, low-land cross-bred flocks, sheep fattening on arable land, and flying flocks. The survey method is being used supplemented by cost accounting records.

(*c*) *Agricultural History.*—Yorkshire is rich in documentary and other material bearing on the great movement in agricultural history, and an investigation is in progress into the evolution of the modern village, the consolidation of the modern farm, the enclosure movement, and the development of the landlord-tenant system.

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115. MANCHESTER UNIVERSITY.

Research on various types of farm management found in the province has continued as in previous years. In making analyses of the management of so many grazing farms, the elements of what may be called its economic structure have been isolated and dissected. The capital employed on farms divides itself naturally into two distinct kinds, the one kind deriving its character more from conditions outside the farmer for which he has little responsibility, the other having direct and almost exclusive reference to his individual character as a manager. For convenience, the first kind may be called " routine capital." It consists of rent, of the necessary charges for fences, of the cost of manure left on the land by cows in grazing, of the cost of putting them out to get grass and of bringing them in to milk. These are charges a man must incur, if he is to be admitted to a farm and to the ranks of farmers. The second kind may be called " enterprise capital." It is that part of capital used to set the soil and other instruments of production in motion, and is the direct expression of the farmer's character as a manager. This is the effective and fruit-producing portion of capital. Farming succeeds or fails according to its amount and direction. To determine what these are, and what they should be for maximum efficiency in farming enterprise, is a great part of the economist's work here.

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116. MIDLAND AGRICULTURAL COLLEGE.

Farm Management.—It has been mentioned in earlier reports that the survey method of economic research into farm management problems would, in the future, replace to a great extent the costing method. This change, of course, could not be effected in one year without causing some inconvenience to farmers, but, by gradual reduction over three years, the department for the year 1930-31 will have only two farms on which complete cost accounts are being kept. These two farms, one arable and the other dairy, will be continued unless the farmers voluntarily resign from the scheme, but is it not proposed, if such an occasion arises, to undertake cost account work on any new farms. During the year under review, the report on the Leicestershire-Northamptonshire Grazing Survey carried on in conjunction with Oxford University has been written up, and is now in the printers' hands. The Wold Survey started in the spring of 1929 has now been completed. Over 150 farms were visited and complete returns were received from 80 farmers, covering an area of approximately 40,000 acres. Individual statistical reports have been sent to each co-operating farmer, and a general report will be published later. Another survey on the lines of the Wold Survey is now being carried on in Derbyshire.

This year the number of farmers supplying records on sugar beet production has been increased, and for the next two or three years

we expect to have 20 growers keeping these enterprise costs. In addition to sending individual reports to the farmers co-operating in the scheme, further information will be sent to the Economics Research Institute, Oxford, where these and other records on sugar beet production will be analysed on a national basis.

Financial accounts are being kept on 10 farms. A scheme for extending the use of farm financial accounts has been drafted in co-operation with Mr. J. R. Bond, the Agricultural Organiser, and has been put before a large number of Derbyshire farmers. The scheme, if a sufficient number of farmers respond, will come into operation in March, 1931.

Marketing.—The Celery Marketing and Grading investigation was completed last year, and the results published in the Report on "Production and Marketing of Celery in the Isle of Axholme," October, 1929.

A grant was received from the Ministry of Agriculture for the purpose of investigating the distribution and consumption of fresh meats in the town of Loughborough. This investigation was started last January, and up to the present the Department has been fortunate in obtaining the co-operation of both meat distributors and consumers.

Out of the 44 butchers or meat salesmen in Loughborough, 32 have supplied monthly records of their sales. Direct canvassing of consumers for the collection of consumption data was made during one winter and one summer month. Information was given by over 500 households in each instance. Other data are still to be collected and analysed.

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117. NEWCASTLE : ARMSTRONG COLLEGE.

The examination of the internal organisation of representative farms through the medium of cost and financial accounts has continued to be a prominent part of the work of the Branch. The list of farms collaborating with the Department in the collection of costings data is the same as last year, namely, seven farms, comprising in all 1,674 acres.

During the winter of 1929-30, a further survey of the returns from Sugar Beet growing in the four northern counties was made, and the results were published in bulletin form in June, 1930. The report contained an analysis of growers, which indicated that the sugar beet crop has not become a stable feature of north country farming, and that acreage has been maintained largely by the extension of the crop to new areas in each of the last four years, with corresponding contractions in those districts where the crop had already been tried. Economic returns from the crop have not compared favourably with results obtained in the other beet growing districts.

In the sphere of Agricultural Marketing, contact has been maintained with the one egg packing station now operating in the northern counties, under the National Mark Scheme. In the north-eastern area, where most poultry keepers have direct access to retail markets, it is perhaps not surprising that the scheme has received little active support from egg producers, while in the rest of the province it is probably true that the operation of the scheme has raised the price level of ungraded eggs to the benefit of producers rather than the authorised packers who pioneer the scheme.

The small organisation of seed potato growers in Cumberland. who are attempting to establish sound stocks of seed potatoes, have continued to consult the Economist on the commercial aspects of their undertaking, although their chief problems at this stage are concerned with the establishment of true and vigorous stocks.

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118. OXFORD UNIVERSITY.

The Advisory Economist is a member of the research staff of the Agricultural Economics Research Institute, and much of the research work carried out at the Institute has been done in the province. (See p. 163.) Thus, the materials for the Farm Management Survey in an area of South Oxfordshire and the Poultry Enterprise Survey were collected in the province, and are now available for advisory purposes.

Work on the compilation and study of farming costs and the analysis of financial accounts has been continued, and results of interest to farmers have been issued from time to time.

In connection with the national study of the economics of the cultivation of sugar beet, returns have been collected from 27 growers.

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119. READING UNIVERSITY.

The cost accounting work of the Department, started in 1924, is being continued. At present six farms are co-operating in the investigation, records for four of these being now available for the whole six-years period. Studies of two of these six-years records are being prepared as " case " studies of farming types.

Enterprise accounts are being kept on certain farms where the development of the enterprises concerned appears to indicate important tendencies in farming policies.

The field work of a farm survey of a dairying district in North-West Dorset has been completed, and the tabulation and analysis of the data collected is also nearly finished. The primary object of this survey is to throw some light on the relative economic advantages of milk-selling and farm cheese-making as a means of disposing of the produce of the dairy herd.

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120. SEALE HAYNE AGRICULTURAL COLLEGE.

Financial Accounts.—The 1928-29 accounts of 75 farms, covering 19,325 acres, were collected, analysed, and reported on during the year. Each farmer received a report comparing his accounts in 1928-29 with those of the previous year, and with the averages of similar farms.

Sugar Beet Costs.—The costs of growing sugar beet in 1929 were investigated on 106 Devon and Cornish farms, relating to 418½ acres. A report "Sugar Beet Costs in Devon and Cornwall, 1929," was issued.

Labour Requirements.—Information was collected during the year on the amount of labour, manual and horse, required by the main types of stock and crops in the province. The data were collected by the survey method.

Parish Statistics.—Through the courtesy of the Statistical Branch of the Ministry, confidential data were supplied relating to the parish statistics of Devon and Cornwall in 1928. This has shown up the different types of farming in the province, and where the parishes have been grouped together the figures have been found useful in depicting to students the effect of soil, climate, topography, markets, etc., on system of farming.

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121. SOUTH EASTERN AGRICULTURAL COLLEGE.

The investigation into farming costs of production and financial results, commenced in 1923, is still going on, and two further reports dealing with pigs and sheep, respectively, have now been published. Abundant evidence of the need for such "long-time" investigations has been obtained, since the results on any one farm fluctuate very considerably from one year to another, and conclusions based upon "short period" results would be radically different from those based on results over a longer period.

Increasing attention is being given to the possibility of devising methods by which the farmer could himself check the efficiency with which he is carrying out the various routine operations on the farm, and a Food Recording Scheme was commenced on about 50 farms in April, 1930. It is obvious that the *quantities* of foodstuffs used by the cows are definitely controllable by the farmer, although this does not apply to the *cost* of these foodstuffs, and experience under the scheme above mentioned shows conclusively that marked economics can be effected where the feeding is carefully controlled. It is hoped in due course to apply the same principles to other sections of the farm.

The investigation of special cases of particular interest from one point of view or another has been continued and data which may ultimately come to have considerable value are steadily accumulating.

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122. ABERDEEN : NORTH OF SCOTLAND COLLEGE OF AGRICULTURE.

The investigation into the profitableness of farming in Scotland was continued, and the scope of the inquiry extended in order to cover all types of farming present in the college area. The method of approach has been through financial accounts, and, unfortunately, many farmers who agreed to co-operate in the scheme preferred to withdraw because of the depressed condition of the industry.

It has been possible, however, to interest other farmers to keep accounts and in this way the number of co-operating farmers has been increased. Each farmer who completed the returns for the crop year 1928–29 received a detailed statement of his position compared with the average result for the group of farms of a similar type, and also an analysed report on his farm.

The collection of more detailed data obtained by cost accounting is being continued on a limited scale, and an enterprise investigation into the profitableness of poultry keeping has been instituted with a view to obtaining some definite economic information with regard to this branch of the industry.

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123. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

The farm accounts investigation has been developed further with respect to two types of farming important in the area :—

(1) Arable farming for stock, particularly sheep, in the Border counties.

(2) Arable farming for sale crops in the Lothians and North of the Forth.

Farms investigated for 1928–29 numbered :—

Type I	17
Type II	29
Miscellaneous	12
	58

In each type several sub-groups have arisen.

Three of these latter—one of Type I and two of Type II—formed the subjects of detailed reports to farmers concerned.

Average profits, in each sub-group, were small, but individual results varied widely. Analysis indicated that, in the Type I (Border) sub-group, this variation was closely connected with the sheep output. Similarly, in the six-course sub-group of Type II (sale crop farm) holdings feeding sheep as well as cattle were more profitable than those carrying cattle only. A wide range in

particular expenses, e.g., wages, was found. Several years' analysis will, however, be required to determine how far such variations are justified by returns.

Schedules of information for statistical purposes were supplied to the Department of Agriculture for Scotland, in respect of practically all the farms investigated.

Some investigation was undertaken regarding the mobility of capital and labour in agriculture.

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124. GLASGOW : WEST OF SCOTLAND AGRICULTURAL COLLEGE.

Economic investigational work in the area has, during the last year, been carried out solely by means of the " Financial Accounting " method. There are possibilities of obtaining cost accounts in small scale poultry enterprises and feeding records from dairy farms.

The account book is similar to that in use at the Aberdeen and Edinburgh Colleges and the method of preparing Trading Accounts is standardised. Account books are provided with duplicate sheets so that, while a copy of all valuations and cash transactions is forwarded to the college, the farmer himself retains a permanent record in convenient book form.

As the majority of farms in the area specialise in milk production those co-operating are drawn almost wholly from this type. The accounts started to date are mainly concentrated in the counties adjoining Glasgow, but individual records are being obtained over a wide area. An attempt is being made to concentrate on particular areas, so that groups of farms operating under more or less comparable conditions may be available for analysis.

Co-operating farms are provided with a summary of transactions at the end of each six months' period, followed later by the standardised Trading Account. After the completion of one year's accounting, comparisons between successive farming periods are made, coupled with, where possible, comparative figures as between farm and farm.

III.

OTHER INVESTIGATIONS.

R.

GRASSLAND.

125. WELSH PLANT BREEDING STATION, ABERYSTWYTH.

The researches and investigations have been carried out with a view to the improvement of mountain and hill grazings. Attention has so far been chiefly confined to the burning of areas of *Molinia* and heather and re-sowing with appropriate seeds mixtures.

The evidence so far collected appears to indicate that the "takes" from surface sowings are very considerably assisted by the application of basic slag or other manures at the time of sowing and investigations are being continued on these lines, while in conjunction with Mr. Chippindale, the Physiologist to the Plant Breeding Station, more intensive work is being undertaken involving various hand treatments on small plots in conjunction with carefully regulated systems of manuring and the sowing of different strains and species of seeds. A large number of seeds mixture plots have been laid down in the counties with a view to comparing indigenous against commercial strains, and a great many botanical analyses have been undertaken with a view to obtaining evidence from these interesting plots.

126. THE IMPROVED MANAGEMENT OF GRASSLAND.

(*a*) WELSH PLANT BREEDING STATION, ABERYSTWYTH.

The scope of this work has been considerably extended during the past season. As a result of the hearty co-operation between a number of hill farmers, investigations are now being conducted on open hill grazings, while the technique of carrying out manurial trials has been improved as a result of experience gained at the Plant Breeding Station.

By a method of sampling before sheep are penned on the plots it has now been possible to obtain yield data under more or less normal grazing conditions. Plots on this basis have been set down at two hill and at one lowland centres, and the technique employed has proved so successful during the current year that it is proposed to extend the scope of this investigation next year.

An investigation has been commenced relative to the mineral content of edible herbs (other than grasses and clovers) which observation shows are eaten to quite a considerable extent by cattle and sheep, both on the hill grazings and on ordinary lowland pastures. The collection of the material has entailed a great deal of work, but it would seem evident that this will prove a fruitful line of investigation. So far 79 samples made up of 50 species have been collected, and are now under chemical investigation.

The work on differential grazing has been extended to include pure species as well as simple seeds mixtures ; this has been possible by resort to the tethered sheep, and these investigations are being supported by chemical analyses.

The preliminary investigations as to the yield of sharply contrasting pasture types and their response to manures, both from the chemical and botanical points of view, have been completed and reported upon during the year under review.

The experiment relative to yield and chemical properties of pedigree strains of a large number of species which has been continued for four years is now the subject of a detailed report.

(*b*) BRISTOL UNIVERSITY.

The experimental campaign outlined in the report for 1929 was continued during the year 1930.

Nitrogenous fertilisers were applied to four of the "intensive" plots. The first application was made during March, the second in June and the third in August.

The season of 1930 again showed the effect of drought conditions at a critical period. The whole of June and the first half of July was very hot and dry, and the same result was obtained as in 1929, *i.e.*, once the "intensive" plots had been grazed down, their recovery was very slow. The dressing of nitrogenous fertiliser applied during

the June drought had very little effect, but the application made later in the summer when there was abundant rain gave a decided response.

During the course of the experiment over 450 samples of herbage have been collected from the various plots. These samples have been dried, pulverised and bottled, and it is hoped that it may be possible to analyse these samples if and when circumstances permit.

The main features of the 1930 results are summarised below :—

(1) The completely manured plots (phosphates, potash and nitrogen in 1929 and nitrogen in 1930) maintained their seasonal productiveness.

(2) The addition of ground chalk in the basal manuring of one plot resulted in a 50 per cent. increase in the " cow days " obtainable from this plot when the 1929 figures are compared with those for 1930.

(3) Useful results were obtained from the application to an " intensive " plot of phosphates and potash alone.

(4) The unmanured intensive plots gave a higher yield than in 1929, but not so good as in 1928.

(5) Owing to the reduction of stock on the estate it was not possible to stock efficiently the experimental area, this has resulted in somewhat lower figures for " cow days per acre " than might have been obtained.

(6) Mixed grazing (*i.e.*, sheep as well as dairy stock and barren beasts) proved very valuable, particularly in keeping plots free from patchiness.

(7) The system has in no way impaired milk yields and although the cake supplied was reduced by half, a month after the cows went on to the plots and omitted altogether after June 11th, the milk yield of the herd was maintained.

(8) The general condition of the stock was satisfactory for the whole season.

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127. PRODUCTION OF SEED POTATOES IN NORTH WALES.

BANGOR: UNIVERSITY COLLEGE OF NORTH WALES.

With a view to testing the possibility of producing seed potatoes on a commercial scale in North Wales, two schemes are in operation. One was commenced in 1927 with Scotch seed of the varieties Great Scot and Kerr's Pink. In the other, which was commenced in 1928, special seed of Irish origin was used, and Sharpe's Express included

with the other two varieties. The stocks were grown each year under standardised conditions in co-operation with growers at fifteen centres.

No increase in the amount of virus diseases during the period of observation was recorded at eight centres, and these are producing healthy, vigorous stocks, well suited for use as seed. At three centres, a slight increase in the amount of infection has occurred, but reasonably good seed is still being produced. The remaining four centres have had to be discarded, two because of rapid and heavy spread of infection, and two for reasons not connected with degeneration of stocks.

The Welsh seed was compared with Scotch seed from Scotland in a series of carefully conducted yield trials. No significant difference in yield between the two classes of seed was found, and it is claimed that the seed produced under the scheme has so far proved at least of equal cropping capacity to Scotch seed.

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128. INVESTIGATION ON METHODS OF MECHANICAL ANALYSIS.

BANGOR: UNIVERSITY COLLEGE OF NORTH WALES.

An account of this work up to the end of August, 1930, will appear in the Proceedings of the Conference on Soil Problems held at Rothamsted in September, 1930.

Sixty-seven samples of soil, all, with the exception of three, from overseas, and received mainly through the Imperial Bureau of Soil Science, are under examination.

A large number of comparisons have been made using different methods of mechanical analysis, viz. :—

1. International Method with pipette analysis.
2. International Method with sedimentation analysis.
3. Sudan Method.
4. Puri Method.
5. International Method modified by substitution of soda for ammonia.

Method 5 appears, by comparison with other methods, to be the most efficient, and works well even for certain soils which give trouble by the International Method. It remains to be seen whether this conclusion is valid for all the soils sent in, and for other soils which will arrive from overseas.

A number of problems arise out of the main enquiry. These relate to the following points :—

(a) The possibility of omitting oxidative treatment for certain classes of soil.

(b) The possibility of using some method for removing soil organic matter which shall dispense with the use of hydrogen peroxide, the use of which presents difficulties in the tropics.
(c) The procedure to be followed in the case of manganiferous soils which are oxidised with difficulty by hydrogen peroxide.
(d) The analysis of highly calcareous soils, involving a study of the use or omission of acids in pre-treatment.
(e) Details of manipulation including washing, shaking, and the desirability of prescribing standard apparatus.
(f) Possible rapid approximate methods.
(g) The analysis of lateritic soils.

The completion of the present programme will carry the work well beyond the period of the original grant, apart from any work on the subsidiary problems to which allusion has been made, and which have at present, only been dealt with in a preliminary way. There is also the strong probability that further supplies of soil amples will arrive from overseas.

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129. KEMP IN THE FLEECE OF WELSH MOUNTAIN SHEEP.

BANGOR: UNIVERSITY COLLEGE OF NORTH WALES.

1. Matings were made between rams and ewes of various degrees of kempiness, in order to determine the extent to which different degrees of kempiness are inherited. The results are not yet available as the lambs born in the spring of 1930 will not be classified for kemp until they are a year old.

2. The examination of these lambs will indicate how far the nature of the birth-coat is a complication, in the following way :— A ram which had a thick birth-coat and which will tend to give lambs with thick birth-coats may himself be relatively free from kemp. (This is the desirable type of sheep). Nevertheless, because he will give a high proportion of lambs with thick birth-coats the kempiness of his lambs on the average may be considerably greater than the lambs of a similar kemp-free ram which had a very thin birth-coat. The breeding results of the seasons 1929-30 and 1930-31 will, it is hoped, shed a considerable amount of light on the inheritance of kempiness, both with reference to different types of birth-coats and also upon the inheritance of kemp irrespective of this feature.

3. Intensive work has been carried out upon the laboratory analysis of fleeces for degrees of kempiness, and the distribution of kemp over the body has been mapped out. It has been found that there is a very definite geographical arrangement. Apart from the

hocks and some other portions of the fleece that would in practice be removed with the skirtings, the highest proportion of kemp is found along the mid-dorsal line, stretching from the top of the tail to a point about mid-way between the small of the back and the withers. The proportion of kemp falls off in every direction from this area, which is sampled as the area of maximum kempiness (apart from the trimmings). It has been found that two sheep with the same proportion of kemp on the middorsal line may have very different amounts of kemp in the rest of the fleece, that is, the extent to which the kemp spreads out from the mid-dorsal line varies widely. Accordingly, to assess the kempiness of a fleece, a second arbitrary point is chosen on the side. It is hoped very shortly to finish this work by determining whether a third sample taken from the shoulder appreciably increases the accuracy of the estimate.

4. Numerous observations have been made to check the accuracy with which the amount of kemp in the fleece can be judged by eye.

5. In order to link up the breeder's judgment of the fleece and the laboratory findings with the manufacturer's opinion, a number of fleeces from the experimental sheep were sorted by an expert, and the percentage of each " sort " determined for each fleece. This has been found to be much the most accurate way of obtaining the manufacturer's judgment, and results of considerable value have emerged :

(*a*) That the process of sorting as carried out by an expert exceeds in accuracy any attempt at grading the entire fleece.

(*b*) That as regards the Welsh fleece there is a good correlation between kempiness, length and fineness as judged by eye, and the subsequent sorting. The multiple correlation including all these three points is about 0·7.

(*c*) A finding of considerable value is that the estimates for kempiness and length alone give almost as close a correspondence as do all three points. Both kempiness and length are features that can readily be judged by the breeder.

6. Observations have been made as to the relationship between any characteristics of value and total fleece weight.

7. The detailed observations on the development of the fleece have been continued, and a number of selected individuals have now been under observation for nearly two years.

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130. *SPARTINA TOWNSENDII* (Rice Grass) IN ESSEX.

ESSEX COUNTY COUNCIL.

During 1930 in order to embrace a wider range of conditions, the plantations at Hadleigh and Goldhanger have been extended, while new smaller ones have been established on Northey Island and at Mundon, Beaumont, Bradwell and Little Wakering.

Along the 250-yards section at Hadleigh, where the plants failed in 1929, further experiments have been made to find the limiting factor or factors, and there are indications that these will be productive of a definite result. In the successful sections the maximum growth recorded in 18 months is a plant 3 feet in diameter.

In Essex, 1929 proved to be a bumper year for seed and seedlings, and it has been possible, therefore, in arranging the plantations in 1930 to test young plants in their first year against cuttings from mature plants.

Germination tests of the seed are being continued.

Overseas Transport of Plants.—Requests for supplies of plants or seeds are still being received, and several thousands of cuttings and seedlings have been successfully shipped to Australia, New Zealand, Bermuda, British West Indies, etc. Until better results are obtained than in the past, it is not recommended that seed be used for export.

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131. INVESTIGATION OF BULB ROTS.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

A species of *Fusarium* occurring frequently in decayed Narcissus bulbs has been shown by inoculations to act as a wound parasite, and is considered to be responsible for a large part of the widespread loss from the rotting of bulbs. Experiments are in progress dealing with the effect of varied atmospheric conditions during storage, the effect of early planting upon the incidence of infection, and upon the existence of resistant varieties. Investigations are being made to determine the mode of entry of the fungus into the bulb. Other experiments deal with the possible use of cold storage and fungicides in controlling the disease.

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132. MOLASSES BEET PULP ENQUIRY.

In the early part of the year 1929, the Ministry's attention was drawn to certain questions connected with the feeding of molasses beet pulp to cattle which seemed to call for an extended investigation. After discussion with the Beet Sugar Factories Committee, a scheme for the conduct of a special series of experiments was drawn up, the Factories Committee agreeing to meet half the cost of the enquiry and to supply the necessary pulp free of charge. The experiments were designed to ascertain the feeding value of molasses beet pulp when included in balanced rations for fattening beasts and dairy cows, and to determine the conditions under which the feeding of pulp may give rise to taint in milk.

Six centres participated in the enquiry during the 1929 season, as follows :—

Feeding to Fattening Beasts.—University Farm, School of Agriculture, Cambridge ; Herts. Farm Institute, Oaklands, St. Albans.

Feeding to Dairy Cows.—Staffs. Farm Institute, Penkridge.

Taint Investigation.—National Institute for Research in Dairying, Reading ; Harper Adams Agricultural College, Newport, Salop ; Midland Agricultural College, Sutton Boningtón, Loughborough.

In the Cambridge and Oaklands trials two main groups of animals were used to test the effects of replacing oats by beet pulp in the ration. The experiments showed that, for the purpose of fattening store beasts, molasses beet pulp would replace oats satisfactorily on a lb. for lb. basis. Further, whereas minor digestive troubles were met with in the animals on the oat rations, no such trouble occurred with the pulp fed animals. At Cambridge as much as as 15 lb. of pulp was fed per head, per day, with successful results.

The experiment on the feeding of pulp to dairy cows was only carried out at one centre, and this part of the enquiry will be repeated at other centres before a definite pronouncement is made. The investigation into the tainting of milk was not concluded, and a further season's work will be conducted into this aspect of the question.

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133. FLUCTUATIONS IN NUMBERS OF WILD RODENTS.

DEPARTMENT OF ZOOLOGY AND COMPARATIVE ANATOMY, OXFORD UNIVERSITY.

Investigations have been continued and extended on the lines of the previous work into the periodic fluctuations in numbers of animals, more especially rodents. From Canada, with the co-operation of the Hudson's Bay Company and the Canadian Government, evidence has been obtained showing the existence of regular cyclic fluctuations in the numbers of rabbits, muskrats, lynx, marten, foxes, lemmings, mice, and certain game birds. Consequently the forecasting of maximum periods of abundance for certain fur bearing animals and rodents has proved to be feasible, and some experimental forecasts made several years ago have now been proved to be correct. Further research has been carried out on the periodicity of mice and voles in Central Europe, and lemmings in Scandinavia, while an intelligence system is being established to obtain information relative to cycles in animal numbers from other parts of the world.

In the British Isles work has been carried out on similar lines, being mainly concerned with the numbers of mice, voles, squirrels, rabbits, hares, and other rodents, all of which have been found to

fluctuate in numbers periodically. The existence and comparative regularity of a four-year cycle in the numbers of mice and voles throughout Great Britain has been established, and further work is being done to elucidate the periodicity of this cycle and its underlying causes. A survey has been made of the spread, distribution, and economic importance of the American Grey Squirrel in the British Isles; the results of this investigation have been placed at the disposal of the Ministry of Agriculture to facilitate the application of measures of control which are under consideration.

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134. INVESTIGATION ON BREEDING SEASONS IN FIELD MICE.

DEPARTMENT OF ZOOLOGY AND COMPARATIVE ANATOMY, OXFORD UNIVERSITY.

Regular supplies of mice come monthly from four districts, and are subjected to a routine observation. This observational part of the work will be continued over the two years for which the investigation is planned. The differences in reproduction in the different districts are extremely interesting and difficult to account for.

A stock of live mice is being gradually built up for the experimental part of the investigation. The experimental investigation will start on the 1st of January, 1931. The refrigerating chamber in which mice will be kept permanently at winter temperature is complete. The winter-growing grasses which are supposed to provide growing food for those mice, which are kept constantly at summer conditions of temperature, length of day, and nutrition, are doing reasonably well.

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135. TRIALS OF HARDY FRUITS FOR COMMERCIAL PURPOSES.

ROYAL HORTICULTURAL SOCIETY AND MINISTRY OF AGRICULTURE.

Varieties representing all kinds of hardy fruits under trial at the Central Station at Wisley now total 287. The material consists, in the main, of new or recently introduced varieties and seedlings regarded by the selection committee as possessing qualities of commercial value. This number includes amongst others, 102 varieties of apple, 21 plums, and damsons, 44 black currants, 38 raspberries. A large collection of varieties of all hardy fruits is established at Wisley, and is added to every year, for comparison with the varieties under trial.

In the past year further varieties have been selected from these growing at the Central Station, for extended trial at the 10 sub-stations at East Malling, Merton, Cambridge, Long Ashton, Elbridge (Cornwall), Perdiswell (Worcester). Emneth (Norfolk), Wisbech, Osgodby (Yorks) and Houghall (Durham). The number of varieties which have been or are about to be distributed to these sub-stations from the Central Station totals 55, and is made up of 20 black currants, 6 gooseberries, 14 raspberries, 5 red currants, 5 apples (as well as 20 new Canadian varieties in small numbers), 3 plums, 2 strawberries.

An inspection of varieties established at the sub-stations carried out during the summer, and records obtained over a period of years, show that good progress is being made and valuable evidence collected upon the behaviour of varieties in the different districts. Many varieties are being tested for their canning value.

The outstanding varieties at the Central Station in the past season were :—

Apples.—Superb, St. Cecilia, Lord Lambourne, Monarch, Herring's Seedling, Crawley Beauty.

Plums.—Early Laxton (ripe a full week before any other market plum), Laxton's Gage, Cambridge Gage and Utility.

Black Currants.—Daniel's September, Goliath, Boskoop Giant, Invincible Giant Prolific, Nigger, Supreme, Seabrook's Black.

Raspberries.—Red Cross, Brockett Hall, Norfolk Giant, Pyne's Royal.

Red Currants.—Laxton's No. 1, Earliest of Fourlands.

Strawberries.—Tardive de Leopold, Oberschlesien.

APPENDIX.

LIST OF DIRECTORS OF RESEARCH INSTITUTES AND HEADS OF ADVISORY CENTRES.

I. RESEARCH INSTITUTES.

A. Soils, Plant Nutrition and Plant Physiology.

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SUBJECT INDEX.

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